CRITERIA AIR POLLUTANT & GREENHOUSE GAS EMISSIONS INVENTORY

GATEWAY NATIONAL RECREATION AREA

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Prepared by ICF Consulting

On behalf of
Environmental Protection Agency
National Park Service
Gateway National Recreation Area

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EXECUTIVE SUMMARY

This report provides an inventory of criteria air pollutant (CAP) and greenhouse gas (GHG) emissions associated with activities at Gateway National Recreation Area (NRA). This national park inventory is the first to include estimates of GHG emissions in addition to CAP emissions. The inventory supports a pilot project initiated by the National Park Service (NPS), with assistance from the Environmental Protection Agency (EPA). The pilot project was designed to establish a Climate Friendly Parks program within the NPS Green Parks Partnership Program. The Climate Friendly Parks program aims to reduce park-related GHG emissions and to inform the public about the climate-friendly actions each park is taking and the reasoning behind the actions.

The purpose of this inventory is to provide the foundation for discussions of CAP and GHG emissions at each of the Gateway units and to assist park officials in identifying ways to reduce these emissions. In addition, the inventory will provide Gateway with a baseline against which future actions to reduce emissions may be compared.

Air emission inventories, of which CAP and GHG inventories are a subset, are often—but not necessarily—prepared for regulatory reasons. Emission regulations or statutes require air emission inventories to determine the amount of pollutants released to the atmosphere. For example, the Clean Air Act, as amended in 1990, sets forth requirements for specific inventories, such as base year inventories for State Implementation Plans. In addition, the development of regulations often necessitates a nationwide inventory of emissions from a particular industry or type of emission source. On a smaller scale, facility-specific inventories are used as the basis for construction and operating permits, determining compliance with existing permit conditions or emission regulations, conducting environmental impact assessments for proposed new emission sources, and for input to human health risk assessment studies. The goal of CAP emission inventories at national parks is threefold: (1) to estimate the scope of in-park emissions compared to the surrounding area; (2) to identify existing and potential strategies to reduce in-park emissions; and (3) to evaluate and ensure compliance of park units under local, state, and federal air pollution regulations.

Although no existing federal regulations limit GHG emissions, concern over the prospect of global warming[1] has prompted the development of corporate, state, regional, national, and global inventories. This national park inventory is the first to include estimates of GHG emissions from activities directly attributable to park operations (e.g., stationary combustion, mobile combustion, refrigeration, fertilizer application). Once emissions from these sources are measured, the park may consider options to reduce emissions. In the interest of considering a full range of options for reducing emissions, the GHG inventory for Gateway also includes "indirect emissions," or emissions from sources that are not directly within the park's control, but which the park has some influence over (e.g., purchased electricity, visitor vehicle emissions, waste management). Consideration of these indirect emissions will both expand the park's portfolio of possible emission reduction actions and enable the park to work with its electricity providers, waste haulers, and visitors to reduce park-related emissions occurring outside park boundaries.

[1] For an explanation of global warming, visit EPA's Global Warming Site: <http://yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html>.

Gateway National Recreation Area consists of three distinct units: Staten Island, Jamaica Bay, and Sandy Hook. These units extend across 26,000 acres in the New York metropolitan area and northern New Jersey. Due to the heterogeneity of the three park units and the available data, we estimated emissions for each unit individually. Additionally, the data gathered by the park units necessitated the use of a baseline year of 2001 for Staten Island and Sandy Hook and 2002 for Jamaica Bay. The sources included in this park inventory were based on (1) whether or not the activity occurred at the park; (2) whether data were available for collection; and (3) whether or not emissions from each source was significant enough to warrant substantial data collection and emission estimation efforts. The CAP sources covered include:

- Stationary Point Sources
  - space and water heating equipment (boilers, furnaces, water heaters)
  - generators
  - fuel storage tanks
  - fireplaces
  - wastewater treatment
- Area Sources
  - campfires
- Mobile Sources
  - highway vehicles
  - nonroad vehicles

The GHG sources reported in this inventory include:

- Carbon Dioxide (CO_2) from Fossil Fuel Combustion
  - direct combustion (including stationary and mobile)
  - indirect – purchased electricity
- Methane (CH_4) and nitrous oxide (N_2O) from Stationary Combustion
- CH_4 and N_2O from Mobile Combustion
  - highway vehicles
  - nonroad vehicles
- High-GWP gases from Refrigeration & Air Conditioning
  - stationary refrigeration and air conditioning
  - motor vehicle air conditioning
- N_2O from Agricultural Soil Management (Fertilizer Use)
- CH_4 and N_2O from Waste Management
  - landfills
  - wastewater treatment

In addition to estimating emissions by park unit, emissions from mobile sources were further disaggregated to provide estimates for Gateway Headquarters and Park Police. In the aggregated totals, Headquarters and Park Police emissions were included in the Staten Island and Jamaica Bay unit totals, respectively, based on their locations in the park.

The remainder of the executive summary provides an overview of emissions for Gateway as a whole and then describes CAP and GHG emissions for each park unit: Staten Island, Jamaica Bay, and Sandy Hook.

1.1 GATEWAY NATIONAL RECREATION AREA EMISSIONS

The following sections (1.1.1 and 1.1.2) include estimates of CAP and GHG emissions for the entire Gateway National Recreation Area.

1.1.1 Criteria Air Pollutant Emissions

CAPs inventoried for Gateway included sulfur dioxide (SO_2[2]), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), particulate matter (PM), and carbon monoxide (CO). Mobile sources accounted for the vast majority of total NO_x, VOC, PM, and CO emissions. Stationary point sources accounted for nearly all of the SO_2 emissions from Gateway. Table ES-1 presents a summary of Gateway CAP emissions for all primary sources.

Table ES-1: Gateway Summary of CAP Emissions

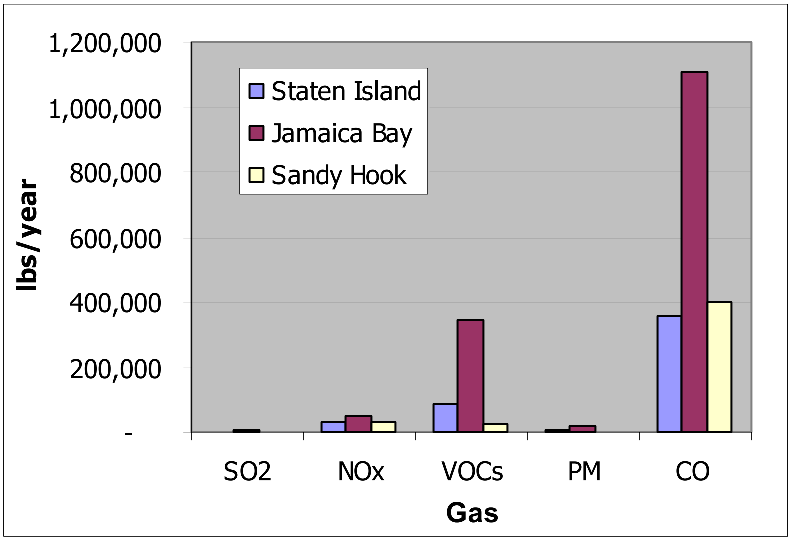
Source Category	Emissions (lbs)				
	SO_2 [a]	NO_x	VOCs	PM	CO
Stationary Point Sources	**6,014**	**20,243**	**1,653**	**1,529**	**11,588**
Space and Water Heating Equipment	5,533	12,936	953	957	9,591
Generators	480	7,303	NE	513	1,573
Fuel Storage Tanks	NA	NA	93	NA	NA
Fireplaces	1	4	385	58	424
Wastewater Treatment	NA	NA	223	NA	NA
Area Sources	**5**	**32**	**2,832**	**428**	**3,123**
Campfires	5	32	2,832	428	3,123
Mobile Sources	**NE**	**90,667**	**452,625**	**26,911**	**1,852,237**
Highway Vehicles	NE	83,817	91,933	2,384	1,126,236
Nonroad Vehicles	NE	6,850	360,641	24,528	726,001
TOTAL CAP EMISSIONS	**6,019**	**110,942**	**457,109**	**28,868**	**1,866,949**

Note: Totals may not sum due to independent rounding.
NA = Not applicable. NE = Not estimated.
[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

The Jamaica Bay Unit accounted for the largest portion of the emissions of each pollutant. As indicated in Figure ES-1, the Jamaica Bay Unit comprised the majority of CO emissions (59 percent), followed by Sandy Hook (21 percent), and Staten Island (19 percent). Similarly, Jamaica Bay accounted for the bulk of VOC emissions, with 345,433 lbs/year (95 percent of park VOC emissions).

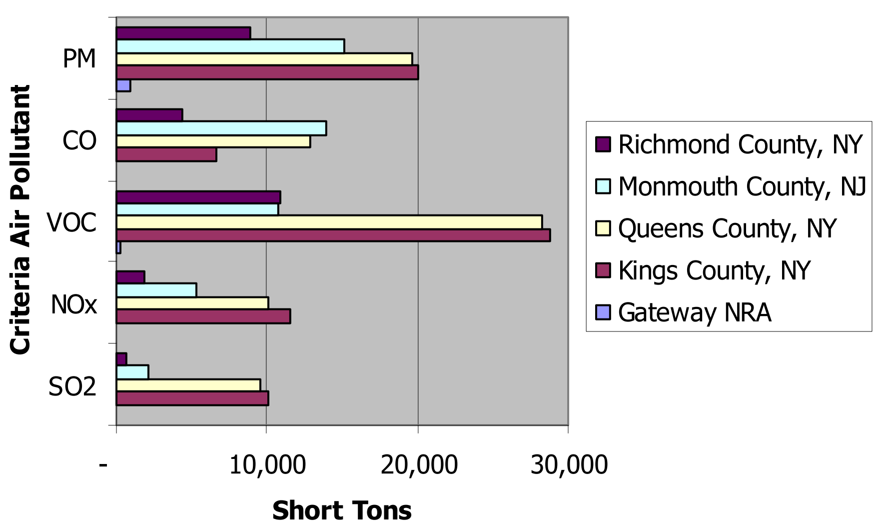
[2] Emissions expressed as SO_2, include SO_2, SO_3, and gaseous sulfates.

Figure ES-1: Gateway CAP Emissions by Gas and Unit



In order to understand the importance of these emissions, it is useful to consider these emissions in the context of the surrounding areas. Figure ES-2 provides an indication of Gateway's emissions as compared to emissions in relevant counties in New York and New Jersey. As the figure shows, Gateway's emissions are very small in comparison to county-level emissions. In fact, Gateway emissions of CO, NO_x, and SO_2 are so low that they don't even show up on this graph. With the exception of CO emissions, Kings and Queens Counties accounted for the majority of emissions, followed by Monmouth and Richmond Counties.

Figure ES-2: Criteria Air Pollutant Emissions of Gateway NRA and Surrounding Counties



These emission totals do not include emissions from the following CAP sources: wildland and prescribed burning, paint and chemical usage, and emissions from non-NPS in-holdings. Emissions from wildland and prescribed burning were not included in this inventory, because Gateway staff indicated that these practices did not take place in the park during the timeframe covered by the inventory. Emissions from paint and chemical usage were too small to quantify, while emissions from a variety of non-NPS in-holdings (e.g., military bases, private residences, and a police station) were not quantified because these data were not readily available. Visitor boat CAP emissions were also not quantified because adequate data were not provided. Additional sources of CAP emissions that were not estimated for specific park units are discussed in the relevant sections of the report.

1.1.2 Greenhouse Gas Emissions

Naturally occurring GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor, and ozone (O_3). Human activities (e.g., fuel combustion in stationary and mobile sources, agriculture, and waste generation) lead to increased concentrations of these gases in the atmosphere. In addition, there are other more powerful GHGs—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)—called high-global warming potential (high-GWP) gases that are created by various industrial processes. GWP is a weighting factor used to measure the ability of a gas to trap heat in the atmosphere. This ability is measured relative to the most commonly occurring GHG, CO_2, which has a GWP of 1. GHGs inventoried for Gateway included CO_2, CH_4, and N_2O, as well as HFCs (i.e., high-GWP gases). In order to compare emissions of these gases with different heat trapping abilities, the GWPs for each gas were used to express emissions for Gateway in metric tons of carbon equivalents (MTCE).[3]

CO_2 from fossil fuel combustion accounted for the greatest portion of GHG emissions (92.9 percent), followed by emissions of HFCs from motor vehicle air conditioning (3.5 percent), and CH_4 and N_2O emissions from mobile combustion (1.6 percent).

Table ES-2 presents a summary of Gateway GHG emissions for all primary sources in MTCE by gas. As shown in Figure ES-3, CO_2 accounted for the vast majority of GHG emissions from Gateway, as it does in virtually all state and national GHG emission inventories.

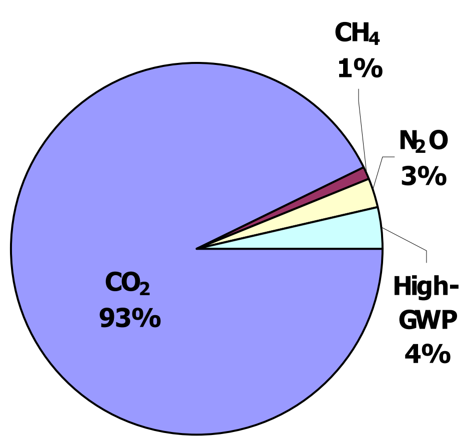
[3] Carbon comprises 12/44 of the mass of CO_2. To convert from CO_2 equivalent to C equivalent, emissions were multiplied by 12/44.

Table ES-2: Gateway Summary of GHG Emissions

Source Category	Emissions (MTCE)				
	CO_2	CH_4	N_2O	High-GWP	Total
CO_2 from Fossil Fuel Combustion	**7,648**	**NA**	**NA**	**NA**	**7,648**
Direct Combustion (including stationary and mobile)	5,702	NA	NA	NA	5,702
Indirect – Purchased Electricity	1,946	NA	NA	NA	1,946
CH_4 and N_2O from Stationary Combustion	**IE**	**3**	**3**	**NA**	**6**
CH_4 and N_2O from Mobile Combustion	**IE**	**6**	**126**	**NA**	**132**
Highway Vehicles	IE	6	125	NA	131
Nonroad Vehicles	IE	+	1	NA	1
Refrigeration and Air Conditioning	**NA**	**NA**	**NA**	**292**	**292**
Stationary Refrigeration and Air Conditioning	NA	NA	NA	0	0
Motor Vehicle Air Conditioning	NA	NA	NA	292	292
Fertilizer Use	**NA**	**NA**	**46**	**NA**	**46**
Waste	**NA**	**73**	**33**	**NA**	**106**
Landfilled Waste	NA	34	NA	NA	34
Wastewater Treatment	NA	39	33	NA	72
TOTAL GHG EMISSIONS	**7,648**	**81**	**209**	**292**	**8,230**

Note: Totals may not sum due to independent rounding.
NA = Not applicable. IE = Included elsewhere. In keeping with international, national, and state GHG guidance and protocols, CO_2 emissions are reported elsewhere (under direct combustion).
+ Does not exceed 0.5 MTCE.

Figure ES-3: Gateway GHG Emissions by Gas



Transportation-related activities comprise the majority of emissions at Gateway. Because these emissions are spread across several inventory source categories (as defined by prevailing GHG inventory guidance), their impact on total emissions is masked in summary tables. Table ES-3 provides a snapshot of these activities and the associated GHG emissions.

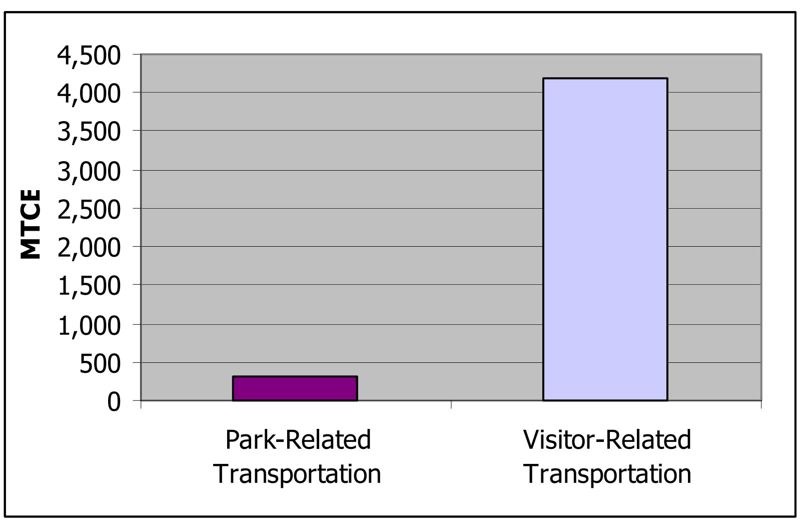
Table ES-3: Park and Visitor-Related Transportation Emissions Comparison

Source Category	Emissions (MTCE)				
	CO_2	CH_4	N_2O	High-GWP	Total
CO_2 from Fossil Fuel Combustion	**4,073**	**NA**	**NA**	**NA**	**4,073**
Park-Related Transportation	291	NA	NA	NA	291
Visitor-Related Transportation	3,782	NA	NA	NA	3,782
CH_4 and N_2O from Mobile Combustion	**IE**	**6**	**126**	**NA**	**132**
Park-Related Transportation	IE	1	7	NA	8
Visitor-Related Transportation	IE	5	119	NA	124
Motor Vehicle Air Conditioning	**NA**	**NA**	**NA**	**292**	**292**
Park-Related Transportation	NA	NA	NA	6	6
Visitor-Related Transportation	NA	NA	NA	285	285

Note: NA = Not applicable. IE = Included elsewhere.

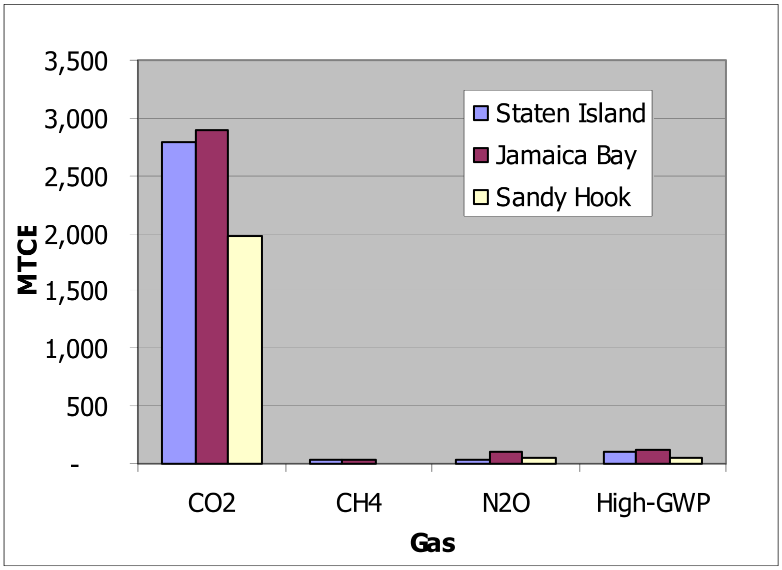
Figure ES-4 illustrates the breakdown of transportation emissions from park operations and emissions associated with park visitors. Emissions from visitor vehicles account for 93 percent of transportation-related emissions in the park. Unfortunately, these numbers do not reflect emissions from visitor boats or Staten Island and Sandy Hook park-owned boats, because we were unable to obtain the necessary data.

Figure ES-4: Park-Related Versus Visitor-Related Transportation at Gateway



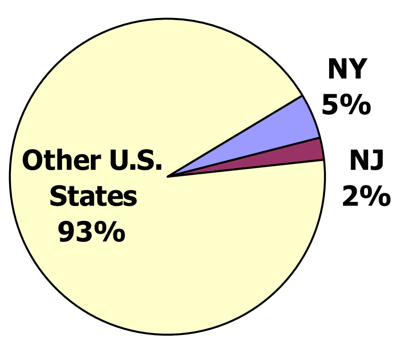
As shown in Figure ES-5, the Staten Island and the Jamaica Bay units accounted for roughly equal portions of total GHG emissions from the Gateway units. Jamaica Bay had slightly higher emissions of CH_4, N_2O, and high-GWP gases than the other units. Sandy Hook accounted for the smallest share of GHG emissions among the park units.

Figure ES-5: Gateway GHG Emissions by Gas and Unit



Unfortunately, Gateway's GHG emissions cannot be compared to emissions at other parks or recreation areas because this is the first GHG inventory of its kind. However, in the context of the two states that house the park, Gateway's emissions are very small. GHG emissions at Gateway in 2001[4] accounted for roughly 0.02 percent of GHG emissions in New Jersey and 0.01 percent of emissions in New York.[5] As shown in Figure ES-6, New Jersey and New York accounted for a fraction of national emissions (2 and 5 percent, respectively).

Figure ES-6: State GHG Emissions as Fraction of National Emissions (1990)



[4] 2002 for Jamaica Bay.
[5] GHG emissions in New Jersey and New York are for 1990, as reported on EPA's Global Warming Site <http://yosemite.epa.gov/OAR/globalwarming.nsf/content/EmissionsStateGHGInventories.html>.

Gateway GHG emission totals do not include emissions from stationary refrigeration and air conditioning. There were no stationary refrigeration/air conditioning GHG emissions to report because the refrigerant used, R-22, is not a high-GWP GHG. Gateway's stationary chiller and air-conditioner equipment at all units has not yet transitioned to HFCs or other GHGs used as substitutes for ozone-depleting substances being phased out of use in order to comply with the Montreal Protocol. GHG emission totals also do not include park-owned boat emissions for Staten Island and Sandy Hook and visitor boat emissions for any of the park units because we were not able to obtain the necessary fuel consumption data.

The sections that follow break out emissions by park unit and present a more detailed discussion of the emission sources.

1.2 Staten Island Unit Emissions

The Staten Island Unit is located on Staten Island in Richmond County, New York. This park unit consists of three sites: Fort Wadsworth, Miller Field, and Great Kills Park. Travel between the sites requires visitors to exit and re-enter park boundaries. Fort Wadsworth is one of the oldest military fortifications in the United States and now houses Gateway's headquarters. Miller Field formerly existed as a landing field and now contains athletic fields used mostly by nearby residents. Great Kills Park serves several recreational purposes, such as jogging, cycling, fishing, boating, beach activities, and bird watching. In 2002, the Staten Island Unit welcomed nearly 3.8 million visitors and supported approximately 55 year-round staff (Lancos and Saslaw 2003).

1.2.1 Criteria Air Pollutant Emissions

Table ES-4 presents a summary of the Staten Island Unit CAP emissions for all primary sources. These emission totals do not include the following CAP sources (in addition to those discussed in the Gateway summary in Section 1.1.1) for the Staten Island Unit: stationary point sources (including fuel storage tanks and wastewater treatment); area sources (including waste disposal); mobile sources (including visitor boats). Details on why CAP emissions from these sources were not estimated for the Staten Island Unit appear in later source-specific sections.

1.2.2 Greenhouse Gas Emissions

Table ES-5 presents a summary of Staten Island GHG emissions for all primary sources in MTCE by gas. Figure ES-7 displays the percentage of GHG emissions by gas for the Staten Island Unit. The greatest sources of emissions in Staten Island were CO_2 from fossil fuel combustion (93.7 percent of total emissions), HFCs from motor vehicle air conditioning (3.7 percent), and waste (1.5 percent).

Table ES-4: Staten Island Summary of CAP Emissions

Source Category	Emissions (lbs)				
	SO_2 [a]	NO_x	VOCs	PM	CO
Stationary Point Sources	**302**	**11,495**	**691**	**811**	**7,896**
Space and Water Heating Equipment	NE	6,908	691	488	6,908
Generators	302	4,587	NA	322	988
Fuel Storage Tanks	NA	NA	NE	NA	NA
Fireplaces	NE	NE	NE	NE	NE
Wastewater Treatment	NA	NA	NA	NA	NA
Area Sources	**+**	**+**	**1**	**+**	**1**
Campfires	+	+	1	+	1
Mobile Sources	**NE**	**17,624**	**83,949**	**5,480**	**351,159**
Highway Vehicles	NE	15,168	13,726	569	202,685
Nonroad Vehicles	NE	2,456	70,222	4,910	148,474
TOTAL CAP EMISSIONS	**302**	**29,120**	**84,640**	**6,291**	**359,056**

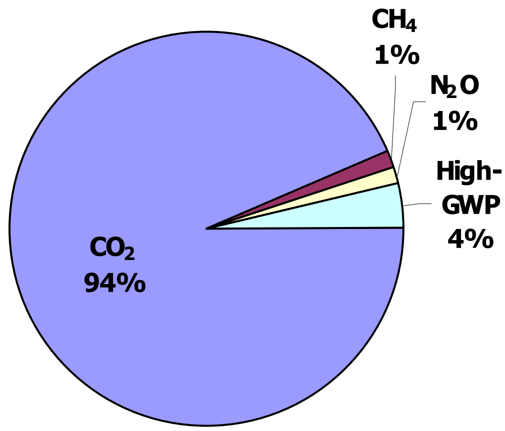
Note: Totals may not sum due to independent rounding.
NA = Not applicable. NE = Not estimated. + Does not exceed 0.5 lbs.
[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

Table ES-5: Staten Island Summary of GHG Emissions

Source Category	Emissions (MTCE)				
	CO_2	CH_4	N_2O	High-GWP	Total
CO_2 from Fossil Fuel Combustion	**2,794**	**NA**	**NA**	**NA**	**2,794**
Direct Combustion (including stationary and mobile)	1,943	NA	NA	NA	1,943
Indirect – Purchased Electricity	850	NA	NA	NA	850
CH_4 and N_2O from Stationary Combustion	**IE**	**2**	**1**	**NA**	**2**
CH_4 and N_2O from Mobile Combustion	**IE**	**1**	**29**	**NA**	**30**
Highway Vehicles	IE	1	29	NA	30
Nonroad Vehicles	IE	+	+	NA	+
Refrigeration and Air Conditioning	**NA**	**NA**	**NA**	**111**	**111**
Stationary Refrigeration and Air Conditioning	NA	NA	NA	0	0
Motor Vehicle Air Conditioning	NA	NA	NA	111	111
Fertilizer Use	**NA**	**NA**	**+**	**NA**	**+**
Waste	**NA**	**33**	**12**	**NA**	**45**
Landfilled Waste	NA	14	NA	NA	14
Wastewater Treatment	NA	18	12	NA	31
TOTAL GHG EMISSIONS	**2,794**	**36**	**42**	**111**	**2,983**

Note: Totals may not sum due to independent rounding.
NA = Not applicable. IE = Included elsewhere. In keeping with international, national, and state GHG guidance and protocols, CO_2 emissions are reported elsewhere (under direct combustion).
+ Does not exceed 0.5 MTCE.

Figure ES-7: Staten Island GHG Emissions by Gas



1.3 JAMAICA BAY UNIT EMISSIONS

The Jamaica Bay Unit is located in Kings County (Brooklyn) and Queens County, New York. This unit includes three major land areas: Floyd Bennett Field (on the mainland), Jamaica Bay Wildlife Refuge, and Rockaway Peninsula. Floyd Bennett Field now contains many cultural resources (e.g., former airport hangars, runways) and supports recreational activities. The Wildlife Refuge is one of the largest bird sanctuaries in the region. Park properties on Rockaway Peninsula include Jacob Riis Park, Fort Tilden, and Breezy Point. Riis Park consists of a famous bathhouse and a beautiful beach. Fort Tilden, another former military site, is a popular spot for artists, performers, sports teams, and naturalists during summer months. Breezy Point houses two private beach clubs and beaches that are accessible to 4-wheel drive vehicles. Two additional destinations for recreational purposes in the Jamaica Bay Unit include Canarsie Pier and Frank Charles Park. In 2002, 4.1 million people visited Jamaica Bay and the unit supported an average year-round staff of 80 (Lancos and Saslaw 2003).

1.3.1 Criteria Air Pollutant Emissions

Table ES-6 presents a summary of Jamaica Bay CAP emissions for all primary sources. These emission totals do not include the following CAP sources (in addition to those discussed in the Gateway summary in Section 1.1.1) for the Jamaica Bay Unit: stationary point sources (including space and water heating equipment – water heaters, fuel storage tanks, wastewater treatment); mobile sources (including visitor boats). Details on why CAP emissions from these sources were not estimated for the Jamaica Bay Unit appear in later source-specific sections.

Table ES-6: Jamaica Bay Summary of CAP Emissions

Source Category	Emissions (lbs)				
	SO_2 [a]	NO_x	VOCs	PM	CO
Stationary Point Sources	**5,711**	**6,453**	**147**	**510**	**2,809**
Space and Water Heating Equipment	5,533	3,737	147	319	2,224
Generators	179	2,716	NA	191	585
Fuel Storage Tanks	NA	NA	NA	NA	NA
Fireplaces	NE	NE	NE	NE	NE
Wastewater Treatment	NA	NA	NA	NA	NA
Area Sources	**+**	**1**	**82**	**12**	**91**
Campfires	+	1	82	12	91
Mobile Sources	**NE**	**44,251**	**345,204**	**20,198**	**1,104,014**
Highway Vehicles	NE	40,644	55,914	864	528,591
Nonroad Vehicles	NE	3,608	289,289	19,334	575,423
TOTAL CAP EMISSIONS	**5,712**	**50,705**	**345,433**	**20,720**	**1,106,914**

Note: Totals may not sum due to independent rounding.
NA = Not applicable. NE = Not estimated. + Does not exceed 0.5 lbs.
[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

1.3.2 Greenhouse Gas Emissions

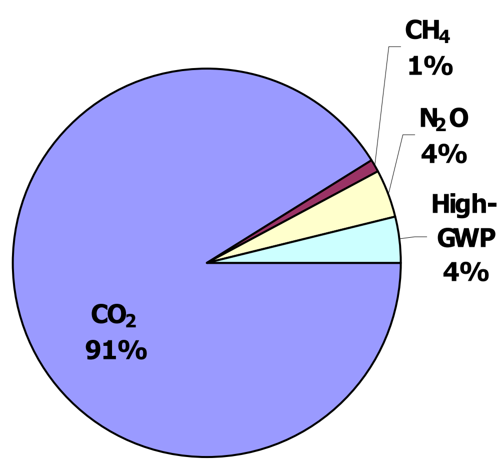
Table ES-7 presents a summary of Jamaica Bay GHG emissions for all primary sources in MTCE by gas. Figure ES-8 displays the percentage of GHG emissions by gas for the Jamaica Bay Unit. The greatest sources of emissions in Jamaica Bay were CO_2 from fossil fuel combustion (91.4 percent of total emissions), HFCs from motor vehicle air conditioning (3.9 percent), and CH_4 and N_2O from mobile combustion (1.6 percent).

Table ES-7: Jamaica Bay Summary of GHG Emissions

Source Category	Emissions (MTCE)				
	CO_2	CH_4	N_2O	High-GWP	Total
CO_2 from Fossil Fuel Combustion	**2,888**	**NA**	**NA**	**NA**	**2,888**
Direct Combustion (including stationary and mobile)	1,980	NA	NA	NA	1,980
Indirect – Purchased Electricity	908	NA	NA	NA	908
CH_4 and N_2O from Stationary Combustion	**IE**	**+**	**2**	**NA**	**2**
CH_4 and N_2O from Mobile Combustion	**IE**	**2**	**50**	**NA**	**51**
Highway Vehicles	IE	2	49	NA	50
Nonroad Vehicles	IE	+	1	NA	1
Refrigeration and Air Conditioning	**NA**	**NA**	**NA**	**123**	**123**
Stationary Refrigeration and Air Conditioning	NA	NA	NA	0	0
Motor Vehicle Air Conditioning	NA	NA	NA	123	123
Fertilizer Use	**NA**	**NA**	**46**	**NA**	**46**
Waste	**NA**	**36**	**13**	**NA**	**50**
Landfilled Waste	NA	16	NA	NA	16
Wastewater Treatment	NA	20	13	NA	34
TOTAL GHG EMISSIONS	**2,888**	**38**	**111**	**123**	**3,159**

Note: Totals may not sum due to independent rounding.
NA = Not applicable. IE = Included elsewhere. In keeping with international, national, and state GHG guidance and protocols, CO_2 emissions are reported elsewhere (under direct combustion).
\+ Does not exceed 0.5 MTCE.

Figure ES-8: Jamaica Bay GHG Emissions by Gas



1.4 Sandy Hook Unit Emissions

The Sandy Hook Unit, which is located in Monmouth County, New Jersey, is a peninsula comprising approximately 1,665 land acres in the Sandy Hook Bay. Sandy Hook played an important role in the early 1900's providing the primary means of navigating the narrow channel and providing coastal defense. Sandy Hook boasts the oldest lighthouse in operation in the United States and the remains of Fort Hancock—an Army Base handed over to NPS in 1974. Visitors are primarily drawn to Sandy Hook for its beaches and for hiking, fishing, and bird watching. In 2002, approximately 2.3 million visitors came to Sandy Hook, and the unit employed nearly 80 year-round staff (Lancos and Saslaw 2003).

1.4.1 Criteria Air Pollutant Emissions

Table ES-8 presents a summary of Sandy Hook CAP emissions for all primary sources. These emission totals do not include the following CAP sources (in addition to those discussed in the Gateway summary in Section 1.1.1) for the Sandy Hook Unit: stationary point sources (including space and water heating equipment – generators); mobile sources (including nonroad vehicles and equipment, and visitor boats). Details on why CAP emissions from these sources were not estimated for the Sandy Hook Unit appear in later source-specific sections.

Table ES-8: Sandy Hook Summary of CAP Emissions

Source Category	Emissions (lbs)				
	SO_2 [a]	NO_x	VOCs	PM	CO
Stationary Point Sources	**1**	**2,295**	**815**	**208**	**883**
Space and Water Heating Equipment	NE	2,291	115	150	458
Generators	NE	NE	NE	NE	NE
Fuel Storage Tanks	NA	NA	93	NA	NA
Fireplaces	1	4	385	58	424
Wastewater Treatment	NA	NA	223	NA	NA
Area Sources	**5**	**31**	**2,748**	**415**	**3,031**
Campfires	5	31	2,748	415	3,031
Mobile Sources	**NE**	**28,791**	**23,473**	**1,234**	**397,064**
Highway Vehicles	NE	28,006	22,342	951	394,960
Nonroad Vehicles	NE	786	1,130	283	2,104
TOTAL CAP EMISSIONS	**5**	**31,118**	**27,036**	**1,857**	**400,978**

Note: Totals may not sum due to independent rounding.
NA = Not applicable. NE = Not estimated.
[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

1.4.2 Greenhouse Gas Emissions

Table ES-9 presents a summary of Sandy Hook GHG emissions for all primary sources in MTCE by gas.

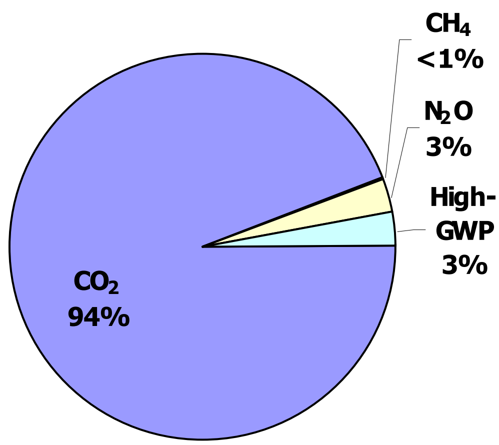
Table ES-9: Sandy Hook Summary of GHG Emissions

Source Category	Emissions (MTCE)				
	CO_2	CH_4	N_2O	High-GWP	Total
CO_2 from Fossil Fuel Combustion	**1,967**	**NA**	**NA**	**NA**	**1,967**
Direct Combustion (including stationary and mobile)	1,779	NA	NA	NA	1,779
Indirect – Purchased Electricity	187	NA	NA	NA	187
CH_4 and N_2O from Stationary Combustion	**IE**	**1**	**1**	**NA**	**1**
CH_4 and N_2O from Mobile Combustion	**IE**	**2**	**48**	**NA**	**50**
Highway Vehicles	IE	2	48	NA	50
Nonroad Vehicles	IE	NE	NE	NA	NE
Refrigeration and Air Conditioning	**NA**	**NA**	**NA**	**58**	**58**
Stationary Refrigeration and Air Conditioning	NA	NA	NA	0	0
Motor Vehicle Air Conditioning	NA	NA	NA	58	58
Fertilizer Use	**NA**	**NA**	**1**	**NA**	**1**
Waste	**NA**	**4**	**8**	**NA**	**11**
Landfilled Waste	NA	4	NA	NA	4
Wastewater Treatment	NA	0	8	NA	8
TOTAL GHG EMISSIONS	**1,967**	**7**	**57**	**58**	**2,088**

Note: Totals may not sum due to independent rounding.
NA = Not applicable. NE = Not estimated. IE = Included elsewhere. In keeping with international, national, and state GHG guidance and protocols, CO_2 emissions are reported elsewhere (under direct combustion).
+ Does not exceed 0.5 MTCE.

Figure ES-9 displays the percentage of GHG emissions by gas for the Sandy Hook Unit. The greatest sources of emissions in Sandy Hook were CO_2 from fossil fuel combustion (94.2 percent of total emissions), HFCs from motor vehicle air conditioning (2.8 percent), and CH_4 and N_2O from mobile combustion (2.4 percent). These emission totals do not reflect GHGs from mobile combustion of nonroad vehicles (including equipment and boats) because the Sandy Hook unit did not provide the necessary fuel consumption data.

Figure ES-9: Sandy Hook GHG Emissions by Gas



2 INTRODUCTION

2.1 BACKGROUND & PURPOSE

This report is an inventory of criteria air pollutant (CAP) and greenhouse gas (GHG) emissions associated with activities at Gateway National Recreation Area. This national park inventory is the first to include estimates of GHG emissions in addition to CAP emissions. The inventory supports a pilot project initiated by the National Park Service (NPS), with assistance from the Environmental Protection Agency (EPA). The pilot project was designed to establish a Climate Friendly Parks program within the NPS Green Parks Partnership Program. The Climate Friendly Parks program aims to reduce park-related GHG emissions and to inform the public about the climate-friendly actions each park is taking and the reasoning behind the actions. Related efforts underway at NPS, EPA, and Gateway that have contributed to the development of the Climate Friendly Parks program are summarized below:

- In August of 1999, NPS embarked on the Natural Resource Challenge, a major effort to improve management of natural resources. As part of this initiative, the NPS Air Resources Division conducts CAP inventories of Class 1 Parks.[6]
- In 2000, the NPS launched an agency-wide Environmental Leadership Program that was defined through three key objectives: improved environmental compliance, the implementation of green practices, and the integration of park–based educational projects for these efforts. In 2002, a Green Partners Program evolved from this program with the objective of identifying key partners that could assist parks in accelerating the implementation of green strategies and practices.
- In 2002, Gateway National Recreation Area created a Green Team for the purpose of increasing staff awareness of environmental issues in the park and catalyzing action on those problems that staff could address.
- Since 1992, EPA has been conducting annual inventories of U.S. GHG emissions and sinks that follow the international guidelines on GHG accounting developed by the Intergovernmental Panel on Climate Change. EPA also has provided guidance and support to states on estimating GHG emissions. The latest guidance (currently in review) will be released shortly as Volume VIII of the Emission Inventory Improvement Program series on developing emission inventories. EPA has also provided financial and technical support for local inventory efforts.
- EPA has provided education and outreach support to parks and outdoor enthusiasts on the topic of climate change since 1998. EPA collaborated with NPS and the U.S. Fish and Wildlife Service in 2001 to produce the *Climate Change, Wildlife, and Wildlands Toolkit for Teachers and Interpreters*.

The Climate Friendly Parks pilot program furthers the NPS Green Partners Program by enlisting the EPA in advancing the understanding of emerging climate change issues in parks. In late 2002,

[6] The Clean Air Act defines Class I areas as national parks over 6,000 acres and wilderness areas and memorial parks over 5,000 acres, established as of 1977 (the date the Clean Air Act was amended). The Clean Air Act affords these Class I areas special protections which are overseen by the federal land manager. The Class I designation does not extend to National Recreation Areas, such as Gateway. A map of Class I parks is available on the Internet at <www2.nature.nps.gov/ardnew/maps/MapsNPSCI.htm>.

Gateway volunteered to be the first park in the pilot program, and thus the first to incorporate climate friendly actions into their "greening" efforts.

The purpose of this inventory is to provide the foundation for discussions of CAP and GHG emissions at each of the Gateway units and to assist park officials in instructing their staff about climate change and in identifying ways to reduce GHG emissions. In addition, the inventory will provide Gateway with a baseline against which future actions to reduce emissions may be compared.

2.2 Rationale for Inventorying CAP and GHG Emissions

The Clean Air Act[7], which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards (OAQPS) set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. These pollutants include sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), lead (Pb), ground-level ozone (O_3), and particulate matter (PM). In 1997, the EPA promulgated revised air quality standards for ground-level O_3 and new standards for fine PM. In addition to lowering the allowable O_3 concentrations, the new standards required further strategies to reduce ozone precursors (i.e., volatile organic compounds (VOCs) and NO_x emissions).

Actions to address increasing greenhouse gas (GHG) emissions began in the early 1990s. In 1992, the United States joined with 154 other nations at the United Nations Conference on Environment and Development (also known as the Earth Summit) in signing the Framework Convention on Climate Change (FCCC). Later that year, the United States became the first industrialized nation to ratify the FCCC Treaty, which came into force on March 21, 1994. The FCCC commits signatories to stabilizing anthropogenic GHG emissions to "levels that would prevent dangerous anthropogenic interference with the climate system." To facilitate these goals, Article 4-1 of the FCCC treaty requires that all parties to the FCCC develop, periodically update, and make available to the Conference of the Parties, national inventories of anthropogenic emissions of all GHGs not controlled by the Montreal Protocol.

The U.S. government has published annual GHG inventories—most recently the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003)—to fulfill its obligation under the FCCC. This series of national inventories tracks the emissions of each GHG, by source, and provides a benchmark for efforts to reduce emissions. To the extent that Gateway can inventory and then track changes in GHG emissions over time, the park may be able to reduce emissions and set an example for park visitors.

Air emission inventories are used to quantify emissions and ensure that air quality is improving. Air emission inventories can range from a simple summary of estimated emissions compiled from

[7] For more information, see: <http://www.epa.gov/oar/oaq_caa.html>.

previously-published emissions data to a comprehensive facility inventory using specific source test data. Though air emission inventories originally focused on emissions from criteria air pollutants (CAPs) and there are currently no federal regulations limiting emissions of GHGs, concern over the prospect of global warming has prompted the development of regional, national, and global GHG inventories.

National Park inventories represent one of the many types of air emission inventories and aim to contribute to three specific goals: (1) estimating the scope of in-park emissions compared to the surrounding area; (2) identifying existing and potential strategies to reduce in-park emissions; and (3) evaluating and ensuring compliance of park units under local, state, and federal air pollution regulations.[8] This inventory—the first of its kind—covers both CAP and GHG emissions.

2.3 Park Description

Gateway National Recreation Area consists of three units: Staten Island, Jamaica Bay, and Sandy Hook. These units, located in the New York metropolitan area and in northern New Jersey, form a natural gateway from the Atlantic Ocean into the estuary between New York and New Jersey. The park was established on October 27, 1972, as America's first urban national park. It extends across 26,000 acres of land and water. See Figure 2.3-1 for a map of Gateway.

Gateway is incredibly diverse. It serves as a site for several former military fortifications defending the New York Harbor, contains the remains of the first airport built in the New York metropolitan area, is home to one of the largest bird sanctuaries in the northeastern United States, contains several miles of beaches, and offers a variety of other recreational opportunities and natural resources. The park receives more than 10 million visitors a year (Lancos 2003), and is one of the most visited parks in the nation. In 2002, Gateway employed approximately 225 people year-round, and approximately 350 people during the peak visitation season (May through September) (Saslaw 2003).

The Staten Island Unit is located on Staten Island in Richmond County, New York. This park unit consists of three sites: Fort Wadsworth, Miller Field, and Great Kills Park. Travel between them requires exiting park boundaries. Fort Wadsworth is one of the oldest military fortifications in the United States and now houses Gateway's headquarters. Miller Field formerly existed as a landing field and now contains athletic fields used mostly by nearby residents. Great Kills Park serves recreational purposes, such as jogging, cycling, fishing, boating, beach activities, and bird watching. In 2002, the Staten Island Unit welcomed approximately 3.8 million visitors and an average year-round staff of 56 (Lancos and Saslaw 2003).

[8] Goals identified in the 2001 *Air Emission Inventory Preparation Protocol* developed by NPS.

Figure 2.3-1: Map of Gateway National Recreation Area

The Jamaica Bay Unit is located in Kings County (Brooklyn) and Queens County, New York. This unit includes three major land areas: Floyd Bennett Field (on the mainland), Jamaica Bay Wildlife Refuge, and Rockaway Peninsula. Floyd Bennett Field now contains many cultural resources (e.g., former airport hangars, runways) and supports recreational activities. The Wildlife Refuge is one of the largest bird sanctuaries in the region. Park lands on Rockaway Peninsula include Jacob Riis Park, Fort Tilden, and Breezy Point. Riis Park consists of a famous bathhouse and a beautiful beach. Fort Tilden, another former military site, is a popular spot for artists, performers, sports teams, and naturalists during summer months. Breezy Point houses two private beach clubs and beaches that are accessible to 4-wheel drive vehicles. Two additional destinations for recreational purposes in the Jamaica Bay Unit include Canarsie Pier and Frank Charles Park. In 2002, approximately 4.1 million people visited the Jamaica Bay Unit and the unit supported an average year-round staff of 80 (Lancos and Saslaw 2003).

The Sandy Hook Unit, which is located in Monmouth County, New Jersey, is a peninsula comprising approximately 1,665 land acres in the Sandy Hook Bay. Sandy Hook played an important role in the early 1900's providing the primary means of navigating the narrow channel and providing coastal defense. Sandy Hook boasts the oldest lighthouse in operation in the United States and the remains of Fort Hancock, an Army Base that was handed over to NPS in 1974. Visitors are primarily drawn to Sandy Hook for its beaches and for hiking, fishing, and bird watching. In 2002, approximately 2.3 million visitors came to Sandy Hook and the unit employed an average of 79 year-round staff (Lancos and Saslaw 2003).

2.4 INVENTORY METHODOLOGY

The methodology for carrying out this CAP and GHG emission inventory for Gateway involved the following steps:

1) Developed a list of data necessary to estimate both CAP and GHG emissions at Gateway;
2) Requested data from Gateway personnel;
3) Reviewed the initial data provided by each park unit;
4) Attended a two-day site visit to Gateway in March 2003 to collect outstanding data;
5) Completed data collection process and reviewed all data;
6) Developed an inventory outline;
7) Estimated emissions for CAP and GHG sources for each park unit; and
8) Developed an inventory report.

Data were collected and reported separately by each park unit. Due to the heterogeneity of the data, both in terms of availability and level of detail, we recognized the need to estimate emissions for each unit individually. Some units could provide enough information on a given emission source to enable us to use a very detailed estimation methodology, while others required a more general approach and necessitated the use of several simplifying assumptions. In effect, we realized that we would need to develop three inventories, one for each unit. Additionally, we decided to develop separate mobile emission estimates for Headquarters and Park Police, because the data were available to do so. Unfortunately, we were not able to identify separated data on stationary sources for Headquarters and Park Police, so stationary emissions from these entities are included in the totals for Staten Island and Jamaica Bay, respectively. Due to data constraints, we were unable to develop estimates for a single year across the entire park. Instead, the Staten Island and Sandy Hook units selected to inventory emissions in 2001, and the Jamaica Bay Unit chose 2002.

CAP emission estimation methodologies follow those outlined in the NPS *Air Emission Inventory Preparation Protocol* and the calculations carried out in other NPS air inventories. The GHG emission estimation approach maintains consistency with the methodologies used in state, national, and international GHG inventories.

Drafts of the inventory outline, emission estimates, and inventory report were submitted to EPA, NPS, and Gateway for review. Comments were incorporated into the final emission estimates and report.

2.5 OVERVIEW OF CAP AND GHG SOURCES & DISCUSSION OF SOURCES INCLUDED IN INVENTORY

Naturally occurring GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor, and ozone (O_3). Human activities (e.g., fuel combustion in stationary and mobile sources, agriculture, and waste generation) lead to increased concentrations of these gases in the atmosphere. In addition, there are other more powerful GHGs—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) that are created by various industrial processes. The ability of a gas to trap heat in the atmosphere can be determined by their Global Warming Potential (GWP). GWP is a weighting factor used to measure the ability of a gas to trap heat in the atmosphere. This ability is measured relative to the most commonly occurring GHG, CO_2, which has a GWP of 1. As a comparison, CH_4 has a GWP of 21. Therefore, one unit of CH_4 is as effective at trapping heat in the atmosphere as 21 units of CO_2. Table 2.5-1 presents a list of GHGs and their associated GWPs. The GHGs inventoried in this report include CO_2, CH_4, N_2O, and HFCs (i.e., high-GWP gases).

CAP gases do not have a direct global warming effect, but indirectly influence the formation or destruction of GHGs. These air pollutants can also act as GHGs, as CO can quickly oxidize to CO_2. The CAPs inventoried in this report include sulfur dioxide (SO_2[9]), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), particulate matter (PM), and carbon monoxide (CO).

As outlined in the NPS *Air Emission Inventory Preparation Protocol*, sources of CAP emissions include stationary, area, and mobile sources. Stationary sources consist of space and water heating equipment (boilers, furnaces, water heaters, woodstoves, and fireplaces), generators, fuel storage tanks, and wastewater treatment. Area sources include wildfires, prescribed burning, campfires, cooking, consumer solvent use, and waste disposal. Mobile sources are subdivided into highway and nonroad vehicles. See Table 2.5-2 for a listing of these source categories.

[9] Emissions expressed as SO_2, include SO_2, SO_3, and gaseous sulfates.

Table 2.5-1: Global Warming Potentials

Gas	GWP[a]
Carbon dioxide (CO_2)	1
Methane (CH_4)[b]	21
Nitrous oxide (N_2O)	310
HFC-23	11,700
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF_4	6,500
C_2F_6	9,200
C_4F_{10}	7,000
C_6F_{14}	7,400
SF_6	23,900

Source: IPCC 1996
[a] 100-year time horizon
[b] The CH_4 GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

Table 2.5-2: CAP Emission Sources

Pollutant/Source Category
CAP Source
Stationary Point Sources
Space and Water Heating Equipment
Generators
Fuel Storage Tanks
Wastewater Treatment
Area Sources
Wildfires [a]
Prescribed Burning [a]
Campfires
Cooking [a]
Consumer Solvent Use [a]
Waste Disposal [a]
Mobile Sources
Highway Vehicles
Nonroad Vehicles

[a] Not estimated.
Note: Wildfires and prescribed burning were not estimated because they are not relevant for Gateway.

In accordance with the GHG emission sources reported by the Intergovernmental Panel on Climate Change (IPCC) in *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC/UNEP/OECD/IEA 1997), EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*, and EPA's *Emission Inventory Improvement Program Guidelines, Vol. VIII Estimating Greenhouse Gas Emissions*, these emission sources include the following activities: energy, industrial processes, solvents and other product use, agriculture, land use change and forestry, and waste. The specific emission sources under these activities are included in Table 2.5-3.

The sources included in this park inventory were based on (1) whether or not the activity occurs at the park; (2) whether data were available for collection; and (3) whether or not emissions from each source was significant enough to warrant substantial data collection and emission estimation efforts. The emission sources that were not estimated for Gateway are noted in Table 2.5-2 and Table 2.5-3. Among the CAP sources, wildfires and prescribed burning do not occur at Gateway and were thus not estimated. Cooking and solvent use were too small to quantify. In accordance with the NPS protocol, because waste disposal emissions are not direct sources from Gateway, they were not estimated.

Among the GHG sources, emissions from coal mining, natural gas and oil systems, international bunker fuels, most of the industrial processes, rice cultivation, agricultural residue burning, and waste combustion were not relevant for Gateway. Other sources, such as solvent use, enteric fermentation and manure management (for horses in the park), and land-use change and forestry were deemed too small to quantify.

Table 2.5-3: GHG Emission Sources

Pollutant/Source Category
GHG Source
Energy
CO_2 from Fossil Fuel Combustion (including stationary and mobile)
CH_4 and N_2O from Stationary Combustion
CH_4 and N_2O from Mobile Combustion
Highway Vehicles
Nonroad Vehicles
Coal Mining [a]
Natural Gas and Oil Systems [a]
International Bunker Fuels [a]
Industrial Processes
CO_2 from Cement Production [a]
CO_2 from Lime Manufacture [a]
CO_2 from Limestone and Dolomite Use [a]
CO_2 from Soda Ash Manufacture and Consumption [a]
N_2O from Nitric Acid Production [a]
N_2O from Adipic Acid Production [a]
Perfluorocarbons from Aluminum Production [a]
HFC-23 from HCFC-22 Production [a]
HFCs and PFCs from Consumption of Substitutes for Ozone-Depleting Substances (Refrigeration & Air Conditioning)
PFC, HFC, and SF_6 Emissions from Semiconductor Manufacture [a]
SF_6 Emissions from Electric Power Transmission and Distribution [a]
SF_6 Emissions from Magnesium Production and Processing [a]
Solvent Use [a]
Agriculture
Enteric Fermentation [a]
Manure Management [a]
Rice Cultivation [a]
Agricultural Soil Management (Fertilizer Use)
Agricultural Residue Burning [a]
Land-use Change and Forestry [a]
Changes in Forest Carbon Stocks
Changes in Carbon Stocks in Urban Trees
Changes in Agricultural Soil Carbon Stocks
Changes in Yard Trimming Carbon Stocks in Landfills
Waste
Landfills
Waste Combustion [a] (sometimes included under Energy)
Wastewater Treatment
Human Sewage

[a] Not estimated.
Note: Coal mining, gas and oil systems, international bunker fuels, most industrial processes, rice cultivation, agricultural residue burning, and waste combustion were not estimated because they were not relevant for Gateway.

2.6 LIMITATIONS

This inventory includes CAP and GHG estimates for all emission source activities that were both occurring at Gateway and were significant enough for quantification, as outlined in Section 2.5. However, inclusion of all these sources for all three park units was limited by a shortened timeframe for gathering data combined with difficulties obtaining the necessary data from personnel at all three park units. The sources that are missing from this inventory are provided in Table 2.6-1, Table 2.6-2, and Table 2.6-3 for Staten Island, Jamaica Bay, and Sandy Hook, respectively.

Table 2.6-1: Staten Island Emission Sources Missing from Inventory

Park Unit/Missing Source	Reason Missing from Inventory
Staten Island Unit	
CAP Emission Sources	
Stationary Point Sources – Fuel Storage Tanks	Unable to estimate using TANKS 4.0 model. This model only allows tanks with minimum dimensions of length 5 and diameter 3, which are much larger than the 1250 capacity provided. Also, there was no yearly throughput data supplied for Staten Island.
Stationary Point Sources – Wastewater (WW)	Estimated for offsite WW treatment; however, these emissions are not included in the totals, because the facilities are not located within park boundaries. This approach is consistent with the NPS protocol for estimating CAP emissions.
Area Sources – Waste Disposal	Estimated from landfills but not included in the totals, because the landfills are not located within park boundaries. This approach is consistent with the NPS protocol for estimating CAP emissions.
Mobile Sources – Nonroad Visitor Boats	Insufficient data on visitor boats to estimate emissions.
GHG Emission Sources	
CO_2 from Fossil Fuel Combustion – Transportation Boats	Insufficient data on fuel consumption to estimate emissions.
CH_4 and N_2O from Mobile Combustion – Nonroad Boats	Insufficient data on fuel consumption to estimate emissions.
Stationary Refrigeration & Air Conditioning	There are no stationary refrigeration/air conditioning GHG emissions to report because the refrigerant being used, R-22, is not a high-GWP gas. Gateway's stationary chiller and air-conditioner equipment has not yet transitioned to HFCs or other substitutes.

Table 2.6-2: Jamaica Bay Emission Sources Missing from Inventory

Park Unit/Missing Source	Reason Missing from Inventory
Jamaica Bay Unit	
CAP Emission Sources	
Stationary Point Sources – Space & Water Heating Equipment: Water Heaters	Insufficient data (fuel consumption or use data) to estimate emissions.
Stationary Point Sources – Fuel Storage Tanks	No storage tanks at Jamaica Bay Unit.
Stationary Point Sources – Wastewater	Estimated for offsite WW treatment; however, these emissions are not included in the totals, because the facilities are not located within park boundaries. This approach is consistent with the NPS protocol for estimating CAP emissions.
Area Sources – Waste Disposal	Estimated from landfills but not included in the totals, because the landfills are not located within park boundaries. This approach is consistent with the NPS protocol for estimating CAP emissions.
Mobile Sources – Nonroad Visitor Boats	Insufficient data on visitor boats to estimate emissions.
GHG Emission Sources	
CO_2 from Fossil Fuel Combustion – Transportation Visitor Boats	Insufficient data on fuel consumption to estimate emissions.
CH_4 and N_2O from Mobile Combustion – Nonroad Visitor Boats	Insufficient data on fuel consumption to estimate emissions.
Stationary Refrigeration & Air Conditioning	There are no stationary refrigeration/air conditioning GHG emissions to report because the refrigerant being used, R-22, is not a high-GWP gas. Gateway's stationary chiller and air-conditioner equipment has not yet transitioned to HFCs or other substitutes.

Table 2.6-3: Sandy Hook Emission Sources Missing from Inventory

Park Unit/Missing Source	**Reason Missing from Inventory**
Sandy Hook Unit	
CAP Emission Sources	
Stationary Point Sources – Generators	Insufficient data (fuel consumption or use data) to estimate emissions.
Area Sources – Waste Disposal	Estimated from landfills but not included in the totals because the landfills are not located within park boundaries. This approach is consistent with the NPS protocol for estimating CAP emissions.
Mobile Sources – Nonroad Vehicles & Equipment	Estimated, but we could not include all nonroad equipment due to insufficient data.
Mobile Sources –Nonroad Visitor Boats	Insufficient data on visitor boats to estimate emissions.
GHG Emission Sources	
CO_2 from Fossil Fuel Combustion – Transportation Boats	Insufficient data on fuel consumption to estimate emissions.
CH_4 and N_2O from Mobile Combustion – Nonroad Vehicles and Other Equipment and Boats	Insufficient data on fuel consumption to estimate emissions.
Stationary Refrigeration & Air Conditioning	There are no stationary refrigeration/air conditioning GHG emissions to report because the refrigerant being used, R-22, is not a high-GWP gas. Gateway's stationary chiller and air-conditioner equipment has not yet transitioned to HFCs or other substitutes.

Transportation Sensitivity Analysis

A major limitation in the estimation of emissions involved incomplete data on the vehicle miles traveled in the park. Data on miles traveled were missing for visitor vehicles in all park units and for park-leased and Headquarters vehicles at Staten Island. Because of the difficulty in characterizing the general routes driven by these vehicles, particularly in the Staten Island and Jamaica Bay units where there are multiple entrances into the park, our estimates assumed that vehicles traveled the entire road distance in a park unit on a one-way trip. This approach presents the upper bound in terms of miles that could have been traveled during the inventoried years. Because of this potential overestimation of transportation emissions within the park, we conducted a sensitivity analysis to compare these emissions estimates to estimates assuming 50 percent less vehicle miles traveled. As seen in Table 2.6-4 and Table 2.6-5, the assumptions made about vehicle miles traveled had a significant impact on emissions. All highway-specific emissions would decrease approximately 47 percent under this sensitivity analysis. Should Gateway choose to inventory these emissions in future years, the accuracy of both CAP and GHG emission estimates will be significantly improved if the park has a better sense of this critical data element.

Table 2.6-4: Sensitivity Analysis on Vehicle Miles Traveled Assumption

	Emissions (lbs)			
Mileage Assumptions	**NO_x**	**VOC**	**PM**	**CO**
Mobile Sources				
Highway Vehicles				
All Miles Traveled	83,817	91,983	2,384	1,126,236
50% Miles Traveled	44,374	49,211	1,252	593,278
Percent Decrease	**47%**	**47%**	**47%**	**47%**
Total CAP				
All Miles Traveled	102,733	457,303	29,269	1,866,139
50% Miles Traveled	63,289	414,530	28,137	1,333,182
Percent Decrease	**38%**	**9%**	**4%**	**29%**

Table 2.6-5: Sensitivity Analysis on Vehicle Miles Traveled Assumption

	Emissions (MTCE)		
Mileage Assumptions	**CO_2**	**CH_4**	**N_2O**
Direct Emissions: Fuel Combustion			
Transportation			
All Miles Traveled	4,073	NA	NA
50% Miles Traveled	2,175	NA	NA
Percent Decrease	**47%**	**NA**	**NA**
CH_4 and N_2O from Mobile Combustion			
Highway Vehicles			
All Miles Traveled	IE	6	125
50% Miles Traveled	IE	3	65
Percent Decrease	**NA**	**47%**	**48%**
Total GHG			
All Miles Traveled	7,648	81	209
50% Miles Traveled	5,750	79	150
Percent Decrease	**25%**	**3%**	**29%**

Note: NA = Not applicable. IE = Included elsewhere. In keeping with international, national, and state GHG guidance and protocols, CO_2 emissions are reported elsewhere (under direct combustion).

3 CRITERIA AIR POLLUTANTS

This section addresses criteria air pollutant (CAP) emissions from Gateway National Recreation Area. The CAPs inventoried in this report include sulfur dioxide (SO_2[10]), oxides of nitrogen (NO_X), volatile organic compounds (VOCs), particulate matter (PM), and carbon monoxide (CO).

Inventories of CAP emissions are often prepared for regulatory reasons. Emission regulations or statutes require air emission inventories to determine the amount of air pollutants released to the atmosphere. For example, the Clean Air Act, as amended in 1990, sets forth requirements for specific inventories, such as base year inventories for State Implementation Plans. In addition, the development of regulations often necessitates a nationwide inventory of emissions from a particular industry or type of emission source. On a smaller scale, facility-specific inventories are used as the basis for construction and operating permits, determining compliance with existing permit conditions or emission regulations, conducting environmental impact assessments for proposed new emission sources, and for input to human health risk assessment studies. The goal of CAP emission inventories at national parks is threefold: (1) to estimate the scope of in-park emissions compared to the surrounding area; (2) to identify existing and potential strategies to reduce in-park emissions; and (3) to evaluate and ensure compliance of park units under local, state, and federal air pollution regulations.

The sources of CAPs at Gateway for which we have estimated emissions include stationary point and area sources, and mobile sources. The following sections provide the results, methodology, and data sources used in the calculation of CAP emissions from these sources for each park unit, Staten Island, Jamaica Bay, and Sandy Hook.

3.1 STATIONARY POINT SOURCE EMISSIONS

Stationary point sources of air pollutants within national parks are typically limited to a few fuel combustion sources, including space heating and water heating equipment (i.e., boilers, furnaces, water heaters, woodstoves), generators, fuel tanks, and fireplaces that are used to service both park personnel and visitors, and wastewater treatment. Gateway National Recreation Area is no exception, and emissions from these stationary point sources are small in magnitude relative to emissions from mobile sources.

CAP emissions from stationary point sources include SO_2, NO_X, VOCs, PM, and CO. In general, a criteria pollutant inventory for point sources is developed using a bottom-up approach, in which each individual process is identified and specific information related to the nature and quantity of emissions, is gathered for each process unit.

Stationary point sources at Gateway made up roughly all of the SO_2 emissions, 18 percent of all NO_X, less than 1 percent of all VOCs, 5 percent of all PM, and roughly 1 percent of all CO emissions. Of stationary point source emissions within Gateway's boundaries, the Staten Island Unit, Jamaica Bay Unit, and Sandy Hook Unit accounted for:

[10] Emissions expressed as SO_2, include SO_2, SO_3, and gaseous sulfates.

- 5, 95, and 0 percent, respectively, of the 6,014 lbs/yr of SO_2 emissions;
- 57, 32, and 11 percent, respectively, of the 20,243 lbs/yr of NO_X emissions;
- 42, 9, and 49 percent, respectively, of the 1,653 lbs/yr of VOC emissions;
- 53, 33, and 14 percent, respectively, of the 1,529 lbs/yr of PM emissions; and
- 68, 24, and 8 percent, respectively, of the 11,588 lbs/yr of CO emissions.

Table 3.1-1 presents the total stationary CAP emissions for each respective park unit and gas, and Table 3.1-2 provides the percent of contribution to these emissions by each unit.

Table 3.1-1: Summary of CAP Emissions from Stationary Sources at Gateway

Park Unit	Emissions (lbs/yr)				
	SO_2 [a]	NO_X	VOC	PM	CO
Total Stationary	**6,014**	**20,243**	**1,653**	**1,529**	**11,588**
Staten Island Unit	302	11,495	691	811	7,896
Jamaica Bay Unit	5,711	6,453	147	510	2,809
Sandy Hook Unit	1	2,295	815	208	883

Note: NE = Not estimated.
[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

Table 3.1-2: Percentage of CAP Emissions from Stationary Sources by Park Unit

Park Unit	Percentage (%)				
	SO_2	NO_X	VOC	PM	CO
Staten Island Unit	5	57	42	53	68
Jamaica Bay Unit	95	32	9	33	24
Sandy Hook Unit	0	11	49	14	8

3.1.1 Space and Water Heating Equipment (Boilers, Furnaces, Water Heaters)

Results

Space and water heating equipment at Gateway NRA resulted in emissions of SO_2, NO_X, VOCs, PM, and CO. The Jamaica Bay Unit accounted for all of the SO_2 emitted from this source within the park boundaries, as Jamaica Bay was the only park unit to provide adequate data for the estimation of SO_2 emissions from this source category. Of the total CAP emissions from space and water heating equipment at Gateway, the Staten Island, Jamaica Bay, and Sandy Hook units accounted for:

- 53, 29, and 18 percent, respectively, of the 12,936 lbs/yr of NO_X emissions;
- 73, 15, and 12 percent, respectively, of the 953 lbs/yr of VOC emissions;
- 51, 33, and 16 percent, respectively, of the 957 lbs/yr of PM emissions; and
- 72, 23, and 5 percent, respectively, of the 9,591 lbs/yr of CO emissions.

Space and water heating equipment comprised 92 percent of all SO_2 emissions, 64 percent of all NO_X emissions, 58 percent of all VOC emissions, 63 percent of all PM emissions, and 83 percent of all CO emissions from stationary CAP sources in the park. Table 3.1-3 presents the CAP emissions estimated from space and water heating equipment by park unit and by gas.

Table 3.1-3: Gateway Summary of Emissions from Space and Water Heating Equipment

Source/Park Unit	Emissions (lbs/yr)				
	SO_2 [a]	NO_X	VOC	PM	CO
Space and Water Heating Equipment Total	**5,533**	**12,936**	**953**	**957**	**9,591**
Staten Island Unit	NE	6,908	691	488	6,908
Jamaica Bay Unit	5,533	3,737	147	319	2,224
Boilers	*5,428*	*3,711*	*146*	*319*	*2,217*
Furnaces	*105*	*27*	*1*	*1*	*7*
Sandy Hook Unit	NE	2,291	115	150	458

Note: NE = Not estimated.

[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

Methodology

Emissions of from stationary source combustion depend on the type of fuel used (e.g., distillate fuel oil, natural gas, wood), the equipment, operating conditions, and maintenance and vintage of the technology. The Intergovernmental Panel on Climate Change (IPCC) outlines two different approaches in *IPCC Guidelines for National Greenhouse Gas Inventories* (1997) for estimating stationary combustion emissions. Although the IPCC Guidelines are for GHG estimation, they provide both GHG and CAP emission factors for stationary combustion. The recommended IPCC approach, Tier 2, employs equipment- and fuel-specific emission factors, which are consistent with those in EPA's *Compilation of Air Pollutant Emission Factors 1998* (AP-42),[11] while the Tier 1 approach uses less detailed information in cases where equipment and technology information are unavailable. Each park unit provided information on its space and water heating equipment to varying levels of detail. Based on the data available, we applied the Tier 2 methodology using the AP-42 emission factors for the Jamaica Bay Unit, and the Tier 1 approach and emission factors for the Staten Island and Sandy Hook units as outlined below.

Jamaica Bay Unit

Among the park units, only the Jamaica Bay Unit was able to provide detailed space and water heating equipment information enabling emissions to be calculated for boilers and furnaces separately. Emissions from water heaters could not be calculated because fuel consumption data were not available. Based on the fuel consumption data for boilers and furnaces, emissions were estimated using equipment-specific emission factors from EPA's *Compilation of Air Pollutant Emission Factors 1998* (AP-42) following the IPCC recommended Tier 2 approach.

The Jamaica Bay Unit reported boiler capacities of less than 100 million British thermal units per hour (Btu/hr) used with either distillate oil (specifically, home heating fuel no. 2) or natural gas. Fuel consumption data for boilers were provided in gallons per year for heating fuel no. 2 and hundred cubic feet per year for natural gas. Fuel consumption data were converted to lb/1000 gallons units for heating fuel and to lb/10^6 standard cubic feet (scf) units for natural gas (i.e., from gallons per year to 1,000

[11] These same emission factors were also provided in the NPS *Air Emission Inventory Preparation Protocol* (2001).

gallons per year and from hundred cubic feet to 10^6 cubic feet). The appropriate emission factors for distillate and natural gas-fired boilers were chosen based on the boiler capacity size, type (residential), and control technology (in this case, none), and taken from EPA's *Compilation of Air Pollutant Emission Factors 1998* (See Table 3.1-4). Fuel consumption data (in the appropriate units) were then multiplied by the boiler, fuel, and gas-specific emission factors to calculate these emissions for the Jamaica Bay Unit. This method follows the formula below:

Emissions (lbs/yr) = Fuel Consumption (1000 gal/yr or 10^6 scf/yr) x Emission Factor (lb/1000 gal or lb/10^6 scf)

CAP emissions from furnaces were calculated using the same approach. Furnaces that used heating fuel no. 2 or natural gas were assumed to be residential. Fuel consumption data (in gallons) were multiplied by the corresponding emission factor for each gas (Table 3.1-4) to estimate CAP emissions.

Table 3.1-4: Tier 2 CAP Space and Water Heating Emission Factors

Source	Type	CAP Emission Factors				
		SO_2	NO_X	VOC	PM	CO
Distillate Fuel Oil Fired [a]		**Emission Factors (lb/1000 gal)**				
Boilers (<100 MMBtu/hr)	Commercial/Institutional, Residential	71	20	0.34	2	5
Furnaces	Residential	71	18	0.713	0.4	5
Natural Gas Fired		**Emission Factors (lb/10^6 cubic feet)**				
Boilers (<100 MMBtu/hr)	Uncontrolled	0.6	100	5.5	7.6	84
Furnaces (<0.3 MMBtu/hr)	Residential Uncontrolled	0.6	94	5.5	7.6	40

[a] Used for heating fuel oil no. 2, a specific product of distillate fuel oil used for space heating.
Source: EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42).

Sandy Hook Unit

The Sandy Hook Unit provided total fuel consumed in all heating equipment in residential buildings. Because it was unclear whether this fuel was consumed in furnaces or in some other type of heating equipment, emissions were estimated assuming that this quantity included fuel use for all space and water heating equipment. We thereby estimated Sandy Hook's emissions for all space and water heating equipment using the IPCC Tier 1 methodology.

To convert distillate fuel oil consumption from gallons to GJ, gallons were first divided by 42 gallons/barrel and multiplied by the heat content for distillate fuel of 5.825 MMBtu/barrel and by 10^6 Btu/MMBtu. Fuel use in gross calorific values (GCV) were then converted to the net calorific values (NCV) using the petroleum heating value conversion of 95 percent.[12] This quantity in Btu was multiplied by 1.055×10^{-6} GJ/Btu to obtain fuel consumption in GJ. This conversion is shown in the equation below:

[12] Fuel use in the United States is typically measured in gross calorific values (GCV). Since the emission factors used are based on fuel reported in net calorific values (NCV), energy content in GCV was converted to NCV using these simplified conversions from the International Energy Agency.

Energy Content (GJ) = Fuel Consumption (gal) ÷ (42 gal/barrel x 5.825 MMBtu Distillate Oil/barrel x 10^6 *Btu/MMBtu) x GCV to NCV conversion x (1.055x*10^{-6} *GJ/Btu)*

The Tier 1 approach uses aggregated emission factors that are based on fuel type and end-use, in this case residential. These emission factors are taken from the IPCC Guidelines (1997) and are provided in grams of gas (NO_x, VOC, CO) per Giga-Joule (g/GJ) (See Table 3.1-5). Because the IPCC does not provide a Tier 1 emission factor for PM, we used a comparable emission factor from the EPA's *Compilation of Air Pollutant Emission Factors 1998* for distillate fuel consumed in boilers because the majority of heating fuel in the other park units occurred in boilers. The resulting PM emissions should be considered conservative because the emission factor for distillate fuel oil fired boilers is higher than that for furnaces.

Emissions were then calculated by multiplying fuel energy content (in GJ) by the appropriate emission factor and converting from grams to pounds. The equation is described below:

Emissions (lbs) = (Fuel Consumption (GJ) x Emission Factor (g/GJ)) ÷ 453.6 g/lb

Staten Island Unit

The Staten Island Unit provided some boiler, furnace, and water heater-specific information, but fuel consumption data were only available as a total of all natural gas consumed by the space and water heating equipment for this park unit. Emissions were calculated using the same IPCC Tier 1 approach as outlined for Sandy Hook above. Based on Staten Island's natural gas usage, the only differences in methodology included:

- fuel consumption was provided in thermals (therms), which was then converted to Btu; and
- a natural gas heating value conversion of 90 percent was used to convert from the gross calorific value to the net calorific value of natural gas.

Table 3.1-5: Stationary CAP Emission Factors Used with IPCC Tier 1 Method

Source	Type	CAP Emission Factors				
		SO_2	NO_X	VOC	PM	CO
			(g gas/GJ)	(g gas/GJ)	(lb/1000 gal)	(g gas/GJ)
Distillate Fuel Oil Fired	Residential	NE	100	5	2	20
					(lb/10^6 ft^3)	
Natural Gas Fired	Residential	NE	50	5	7.6	50

Note: NE = Not estimated

Source: NO_x, VOC, and CO emission factors from IPCC 1997; PM emission factors from AP-42 for boilers.

Data Sources

Table 3.1-6 presents the sources of activity data and emission factors used in the CAP emission calculations for space and water heating equipment.

Table 3.1-6: Data Sources for CAP Emission Estimates of Space and Water Heating Equipment

Source/Park Unit	Data Source
Stationary Sources: Space and Water Heating Equipment	
Staten Island Unit	
Fuel Consumption Data	Dexter, 2003.
Emission Factors for all Natural Gas Space and Water Heating Equipment for NO_X, VOC, and CO	IPCC/UNEP/OECD/IEA, 1997.
Jamaica Bay Unit	
Fuel Consumption Data	Collier, 2003.
Emission Factors for Distillate Fuel Boilers, Furnaces, and Water Heaters for SO_2, NO_X, CO, and PM	EPA, 1998. Table 1.3-1.
Emission Factors for Natural Gas Boilers, Furnaces, and Water Heaters for NO_X and CO	EPA, 1998. Table 1.4-1.
Emission Factors for Natural Gas Boilers, Furnaces, and Water Heaters for SO_2, VOC, and PM	EPA, 1998. Table 1.4-2.
Sandy Hook Unit	
Fuel Consumption Data	Hansen and Diodato, 2003.
Emission Factors for all Distillate Fuel Space and Water Heating Equipment for NO_X, VOC, and CO	IPCC/UNEP/OECD/IEA, 1997.

3.1.2 Generators

Results

CAP emissions from generators include SO_2, NO_X, VOCs, PM, and CO. We were only able to estimate these emissions for two of the three units because Sandy Hook was unable to provide fuel consumption data. However, the total emissions reported from generators likely underestimates the actual emissions resulting from this source in Gateway because the Sandy Hook Unit houses generators that consume home heating fuel no. 2. Of the total CAP emissions from generators within the park boundaries, Jamaica Bay Unit and Staten Island Unit accounted for:

- 37 and 63 percent, respectively, of the 480 lbs/yr of SO_2 emissions;
- 37 and 63 percent, respectively, of the 7,303 lbs/yr of NO_X emissions;
- 37 and 63 percent, respectively, of the 513 lbs/yr of PM emissions; and
- 37 and 63 percent, respectively, of the 1,573 lbs/yr of CO emissions.

Generators comprised 8 percent of all SO_2 emissions, 36 percent of all NO_X emissions, 34 percent of all PM emissions, and 14 percent of all CO emissions from stationary point sources. Table 3.1-7 presents the emissions from generators by gas and by unit.

Table 3.1-7: Gateway Summary of CAP Emissions from Generators

Source/Park Unit	Emissions (lbs)			
	SO_2 [a]	NO_x	PM	CO
Generators	**480**	**7,303**	**513**	**1,573**
Staten Island Unit	302	4,587	322	988
Jamaica Bay Unit	179	2,716	191	585
Sandy Hook Unit	NE	NE	NE	NE

Note: NE = Not estimated due to insufficient fuel consumption data.

[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

Methodology

Due to data constraints, we estimated emissions from this source using fuel consumption data rather than generator power output. All three units relied on home heating fuel no. 2 as the primary fuel for their generators. Because the generators at the three park units are all rated no greater than 200 kilowatts (kW), we chose the fuel input emission factor for generators rated less than 448 kW from EPA's *Compilation of Air Pollutant Emission Factors 1998* (See Table 3.1-8). Calculating generator emissions involved converting fuel consumption from gallons to million British thermal units (MMBtu) and multiplying by the designated emission factors (in lb/MMBtu units) as shown in the following equation:

$$\textit{Emissions (lbs/yr)} = \textit{Fuel Consumption (gal)} \div (\textit{42 gal/barrel x 5.83 MMBtu Distillate Oil/barrel x } 10^6) \textit{ x Emission Factor (lb/MMBtu)}$$

Emissions from VOCs are not estimated because based on the "fuel input" method of emissions calculation, there is no VOC emission factor for distillate fuel generators.

Table 3.1-8: CAP Generator Emission Factors

Source	CAP Emission Factors (lb/MMBtu)			
	SO_x	NO_x	PM	CO
Distillate Fuel Oil				
Generators ($\leq$ 448 kW)	0.29	4.41	0.31	0.95

Source: EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42).

Data Sources

Table 3.1-9 presents the sources of activity data and emission factors used in the CAP emission calculations for generators.

Table 3.1-9: Data Sources used for CAP Emission Estimates of Generators

Source/Park Unit	Data Source
Stationary Sources: Generators	
All Units	
Emission Factors for Distillate fuel generators for SO_X, NO_X, PM, and CO	EPA, 1998.
Staten Island Unit	
Fuel Consumption Data	Dexter, 2003.
Jamaica Bay Unit	
Fuel Consumption Data	Collier, 2003.
Sandy Hook Unit	
Generator Properties	Hansen and Diodato, 2003.

3.1.3 Fuel Storage Tanks

Results

VOCs are the primary pollutant emitted from fuel storage tanks. While storage tanks exist at Staten Island, emissions could not be calculated due to constraints in applying the model with their data (explained in the methodology section). In the Jamaica Bay Unit, all underground storage tanks have been removed. Therefore, Sandy Hook Unit was responsible for all 93 lbs of VOC emissions from this source at Gateway NRA. Fuel storage tanks comprised 6 percent of all VOC emissions from stationary sources and 0.02 percent of total VOC emissions at Gateway. Table 3.1-10 presents the VOC emissions from fuel storage tanks at Gateway.

Table 3.1-10: Gateway Summary of VOC Emissions from Fuel Storage Tanks

Source/Park Unit	VOC Emissions (lbs/yr)
Fuel Storage Tanks	**93**
Staten Island Unit	NE
Jamaica Bay Unit	NA
Sandy Hook Unit	93

Note: NA = Not applicable; NE = Not estimated.

Methodology

Emissions from fuel storage tanks were estimated using the Environmental Protection Agency's TANKS version 4.09 Windows-based software, which is available online at http://www.epa.gov/ttn/chief/software/tanks. Using information on storage tank location, shell dimensions, stored liquid, and other properties, the TANKS software is able to generate reports for single and multiple tanks. However, the software itself is only able to read-in the properties of single fuel tank units, which makes use of this software time-intensive for multiple tanks.

Available information for tanks found in the Sandy Hook Unit included the type of organic fuel contained in the storage tanks, whether the tanks were above or underground, the capacity sizes, and the yearly throughputs. The tanks in the Sandy Hook Unit were assumed to be horizontal storage tanks based on their small capacity size, while the shell dimensions of these tanks were adjusted according to the capacity and dimensions of an example entry in the TANKS model of a horizontal storage tank in Raleigh, NC. For aboveground storage tanks, the shell color was assumed to be white and the shell condition was assumed to be good. Average temperature, wind speed, and atmospheric pressure inputs were determined by the selection of New York City, NY as the closest site. Although the Sandy Hook Unit is located in New Jersey, we chose the New York City location as a single site for Gateway to apply the same conditions to the entire park.

The high number of storage tanks in place at Sandy Hook and the requirements necessary to run the TANKS software made it infeasible to run TANKS for each individual fuel tank. Instead, we used the sum of the capacities and yearly throughput for each type of storage tank (e.g., underground storage tank containing heating fuel no. 2, aboveground storage tank containing diesel fuel) was used to estimate emissions. Aside from the difficulty of entering each tank into the model separately, we were limited by the TANKS model, which required minimum shell dimension of length 5 and diameter 3. Because the capacities of many of the individual storage tanks in the Sandy Hook Unit fell below these dimension limits, emissions from these tanks could not be estimated unless they were aggregated in some way. This model requirement precluded us from estimating fuel storage tank emissions from Staten Island entirely because the total capacity of all tanks was less than the minimum shell dimensions allowed in the model.

The final emission estimates were generated as outputs from the TANKS model based on the inputs described above.

Data Sources

Table 3.1-11 presents the sources of activity data and emission factors used in the CAP emission calculations for fuel storage tanks.

Table 3.1-11: Data Sources for CAP Emission Estimates of Fuel Storage Tanks

Source/Park Unit	Data Source
Stationary Sources: Fuel Storage Tanks	
All Units	
EPA TANKS software v.4.09	EPA, 1998.
Staten Island Unit	
Fuel Storage Tank Data	Dexter, 2003.
Sandy Hook Unit	
Fuel Storage Tank Data	Hansen and Diodato, 2003.

3.1.4 Fireplaces

Results

Fireplaces only exist in the Sandy Hook Unit. CAP emissions include NO_X, VOCs, PM, CO, and SO_2. The totals for these emissions are listed in Table 3.1-12. Fireplaces comprised 0.02 percent of all

NO_X emissions, 23 percent of all VOC emissions, 4 percent of all PM emissions, 4 percent of all CO emissions, and 0.01 percent of all SO_2 emissions from stationary sources.

Table 3.1-12: Gateway Summary of Emissions from Fireplaces

Park Unit	Emissions (lbs/yr)				
	SO_2 [a]	NO_x	VOC	PM	CO
Staten Island Unit	NA	NA	NA	NA	NA
Jamaica By Unit	NA	NA	NA	NA	NA
Sandy Hook Unit	1	4	385	58	424

Note: NA = Not Applicable
[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

Methodology

Available data for fireplaces from the Sandy Hook Unit included the fuel type used and the fuel consumed in terms of cords of wood per year. Emissions from fireplaces were estimated by converting fuel consumption from cords to tons and multiplying by the appropriate AP-42 emission factors (in Table 3.1-13), as shown in the following equation:

Emissions (lbs/yr) = Fuel Consumption (cords) x 1.12 short tons/cord x Emission Factor (lb/short ton)

Table 3.1-13: CAP Fireplace Emission Factors

Source	CAP Emission Factors (lb/short ton)				
	SO_x	NO_x	VOC	PM	CO
Fireplaces					
Wood	0.4	2.6	229	34.6	252.6

Source: EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42).
Note: The emission factors for campfires are the same as those for fireplaces.

Data Sources

Table 3.1-14 presents the data sources for activity data and emission factors used in the CAP emission calculations for fireplaces.

Table 3.1-14: Data Sources used for CAP Emission Estimates of Fireplaces

Source/Park Unit	Data Source
Stationary Sources: Fireplaces	
Sandy Hook Unit	
Fuel consumption	Hansen and Diodato. 2003.
Emission Factors for fireplaces/campfires for SO_X, NO_X, VOC, PM, and CO	EPA, 1998. Table 1.9-1.

3.1.5 Wastewater Treatment

Results

Gateway contains one wastewater treatment plant (WWTP), which is located in the Sandy Hook Unit. Wastewater treatment plants are a source of VOC emissions, and based on the NPS *Air Emission Inventory Preparation Protocol*, only emissions from onsite wastewater treatment are included in the CAP portion of this inventory. Because Sandy Hook was the only unit to house a wastewater treatment facility, this unit was responsible for all emissions from this source. These emissions comprised 13 percent of all VOC emissions from stationary point sources and 0.05 percent of total VOC emissions from the park. Estimated VOC emissions are reported in Table 3.1-15.

Table 3.1-15: Gateway VOC Emissions From Wastewater Treatment

Source/Park Unit	Emissions (lbs VOCs)
	223
Staten Island Unit	NA
Jamaica Bay Unit	NA
Sandy Hook Unit	223

Note: NA = Not applicable because wastewater treatment does not take place within park boundaries.

Methodology

The methodology employed for estimating CAP emissions from wastewater treatment is consistent with the NPS *Air Emission Inventory Preparation Protocol*. Data on the actual volume of wastewater treated, as well as the capacity of the wastewater treatment plant were collected from Sandy Hook. VOC emissions from wastewater treatment activities were then estimated by multiplying the gallons of wastewater treated by an emission factor of 8.9 lbs of VOCs emitted for every million gallons of wastewater treated (U.S. NPS 2001) and dividing by 10^6 million gallons. The actual and potential treatment volumes of the Sandy Hook WWTP are given in Table 3.1-16 along with actual and potential emissions.

Table 3.1-16: Wastewater Treatment Emissions Data

Park Unit	Wastewater Treated (gal/year)	Design Capacity (gal/year)	VOC Emission Rate (lbs VOCs/million gal)	VOC (lbs/yr)	
				Actual	Potential
Sandy Hook WWTP	25,000,000	102,200,000	8.9	222.5	909.6

Data Sources

Table 3.1-17 presents the sources for activity data and emission factors used in the CAP emission calculations for wastewater treatment.

Table 3.1-17: Gateway Summary of Wastewaster CAP Data Sources

Source/Park Unit	Data Source
All Units	
VOC Emissions Factor	NPS, 2001.
Sandy Hook Unit	
WWTP Average Flow	Cloonan, 2003.

3.2 AREA SOURCE EMISSIONS

As for stationary point sources, criteria pollutant inventories for stationary area sources are developed using a bottom-up approach, in which each individual process is identified and specific information related to the nature and quantity of emissions, is gathered for each process unit. Area sources include those activities that are too small or too numerous to be inventoried as individual point sources. Examples include wildfires, prescribed burning, campfires, cooking, consumer solvent use, and waste disposal. The only area sources inventoried at Gateway were campfires. The decision to include or exclude area sources was based on relevancy to the park, availability of data, and potential magnitude of emissions.

Campfires emit NO_X, VOCs, PM, CO, and SO_2. At Gateway, area source emissions comprised 0.08 percent of all SO_2 emissions, 0.03 percent of all NO_X emissions, 0.62 percent of all VOC emissions, 1.48 percent of all PM emissions, and 0.17 percent of CO emissions.

The Staten Island Unit accounted for 0.04 percent of emissions of each CAP emitted from campfires. The Jamaica Bay Unit accounted for 3 percent of emissions of each CAP. The Sandy Hook Unit made up the highest percentage (97 percent) of emissions of each type of CAP emitted from campfires. Table 3.2-1 presents the CAP emissions from area sources.

Table 3.2-1: Gateway Summary of Emissions from Area Source Emissions

Park Unit	Emissions (lbs/yr)				
	SO_2 [a]	NO_x	VOC	PM	CO
Total Area Source Emissions	**5**	**32**	**2,832**	**428**	**3,123**
Staten Island Unit	0	0	1	0	1
Jamaica Bay Unit	0	1	82	12	91
Sandy Hook Unit	5	31	2,748	415	3,031

Note: Totals may not add due to independent rounding.
[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

3.2.1 Campfires

Results

CAP emissions from campfires include NO_X, VOCs, PM, CO, and SO_2. Table 3.2-2 provides the total emissions for Gateway by park unit and pollutant. Campfires account for all area source emissions at Gateway.

Among the park units, the greatest number of campfires takes place at Sandy Hook. These campfires include those by Boy Scouts at the 6 campsite locations at Sandy Hook. At Jamaica Bay, there are 4 campsite locations and fewer campers. The Staten Island Unit only allows campfires on special occasions. As such, Sandy Hook Unit accounted for approximately 97 percent of the 5 lbs/yr of SO_2 emissions, of the 32 lbs/yr of NO_X emissions, of the 2,832 lbs/yr of VOC emissions, of the 428 lbs/yr of PM emissions, and of the 3,123 lbs/yr of CO emissions from campfires. Campfire emissions at the Jamaica Bay Unit and the Staten Island Unit, comprised the remaining 3 and 0.04 percent, respectively, of each air pollutant.

Table 3.2-2: Gateway Summary of Emissions from Campfires

Park Unit	Emissions (lbs/yr)				
	SO_2 [a]	NO_x	VOC	PM	CO
Total Stationary	**5**	**32**	**2,832**	**428**	**3,123**
Staten Island Unit	0	0	1	0	1
Jamaica Bay Unit	0	1	82	12	91
Sandy Hook Unit	5	31	2,748	415	3,031

[a] Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates.

Methodology

To estimate emissions from campfires, wood consumption (lbs) for campfires was estimated by multiplying the number of camps by the average pounds (lbs) of wood used per campfire, which the Sandy Hook Unit assumed to be 10 lbs. Emissions were then calculated by converting wood consumption into short tons and multiplying by the AP-42 emission factors for each type of pollutant (in Table 3.2-3). These calculations followed the equations below:

$$\textit{Fuel Consumption/yr (short tons)} = \textit{(Number of Camps x average 10 lb wood/campfire)} \div \textit{2000 lbs/short ton}$$

$$\textit{Emissions (lbs/yr)} = \textit{Fuel Consumption (short tons) x Emission Factor (lb/short ton)}$$

Table 3.2-3: CAP Campfire Emission Factors

Source	CAP Emission Factors (lb/short ton)				
	SO_x	NO_x	VOC	PM	CO
Campfires					
Wood	0.4	2.6	229	34.6	252.6

Source: EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42).
Note: The emission factors for campfires are the same as those for fireplaces.

Data Sources

Table 3.2-4 presents the sources of activity data and emission factors used in the CAP emission calculations for campfires.

Table 3.2-4: Data Sources used for CAP Emission Estimates of Campfires

Source/Park Unit	**Data Source**
All Units	
Emission Factors for fireplaces/campfires for SO_X, NO_X, VOC, PM, and CO	EPA, 1998. AP-42, Table 1.9-1.
Staten Island Unit	
Campsite data	Dexter, 2003.
Jamaica Bay Unit	
Campsite data	Wolff, 2003.
Sandy Hook Unit	
Campsite data	Hansen and Diodato, 2003.

3.3 MOBILE SOURCE EMISSIONS

Mobile sources account for the vast majority of CAP emissions at Gateway, as they do at many other national parks. CAP emissions from mobile sources include NO_x, VOCs, PM, and CO. SO_2 emissions from mobile sources were not included in this analysis. NO_x, VOCs, PM, and CO emissions from both highway and non-road mobile sources accounted for more than 82 percent of all NO_x, 99 percent of all VOCs, 93 percent of all PM, and 99 percent of all CO emitted from Gateway National Recreation Area. Of the 90,667 lbs/year of NO_x emitted from this source, Staten Island Unit, Jamaica Bay Unit, and Sandy Hook Unit accounted for 19, 49, and 32 percent, respectively. Of the 452,625 lbs/year of VOCs emitted, they accounted for 19, 76 and 5 percent, respectively. Of the 26,911 lbs/year of PM emitted from this source within the park boundaries, the Staten Island, Jamaica Bay, and Sandy Hook units accounted for 20, 75, and 5 percent, respectively. Finally, of the 1,852,237 lbs/year of CO emitted, they accounted for 19, 60, and 21 percent, respectively. The reason Jamaica Bay's emissions from highway vehicles are higher than the other units is because Jamaica Bay has more vehicles and Jamaica Bay vehicles are older (i.e., higher emitting) than vehicles at the other units. Nonroad emissions are highest for Jamaica Bay due to the inclusion of higher Park Police patrol boats. In contrast, Sandy Hook's nonroad emissions are noticeably lower because Sandy Hook has fewer park boats. Table 3.3-1 presents the total mobile CAP emissions for each of the park units by gas.

Table 3.3-1: Gateway Summary of CAP emissions from Mobile Sources

Source/Park Unit	Emissions (lbs/year)			
	NO_x	VOCs	PM	CO
Highway Vehicles	**83,817**	**91,983**	**2,384**	**1,126,236**
Staten Island Unit	15,168	13,726	569	202,685
Jamaica Bay Unit	40,644	55,914	864	528,591
Sandy Hook Unit	28,006	22,342	951	394,960
Nonroad Vehicles	**6,850**	**360,641**	**24,528**	**726,001**
Staten Island Unit	2,456	70,222	4,910	148,474
Jamaica Bay Unit	3,608	289,289	19,334	575,423
Sandy Hook Unit	786	1,130	283	2,104
Total	**90,667**	**452,625**	**26,911**	**1,852,237**

3.3.1 Highway Vehicles (Park-Owned, Park-Leased, Park Police, Headquarters, and Visitor Vehicles)

Highway vehicle emissions at Gateway were estimated for three separate fleets for each of park unit: park-owned vehicles, park-leased vehicles, and visitor vehicles. In addition, two other fleets were evaluated separately, Gateway Headquarters vehicles and Park Police vehicles, which are reported in the Staten Island and Jamaica Bay Unit totals, respectively.

Results

Table 3.3-2 presents emissions for each of the vehicle fleets. Headquarters and Park Police vehicles are listed separately under emissions for Staten Island and Jamaica Bay, respectively. Visitor vehicles were by far the largest of the vehicle fleets in the park and contribute the most to the emissions from each of the units. For Staten Island they comprise 98, 97, 95, and 92 percent of all the PM, NO_x, CO, and VOCs from highway mobile sources, respectively, from the unit. For Jamaica Bay, they comprise 92, 91, 90, and 90 percent of the highway mobile PM, NO_x, CO, and VOCs emissions from the unit. At Sandy Hook Unit, these emissions comprise 95, 96, 98, and 97 percent of all the highway mobile PM, NO_x, CO, and VOCs emissions, respectively.

Table 3.3-2: Gateway Summary of PM, NO_x, CO and VOCs Highway Mobile Emissions

Source/Park Unit	Emissions (lbs/year)			
	NO_x	VOCs	PM	CO
Highway Mobile Emissions	**83,817**	**91,983**	**2,384**	**1,126,236**
Staten Island Unit	**15,168**	**13,726**	**569**	**202,685**
Park-Owned Vehicles	148	48	5	453
Park-Leased Vehicles	200	115	5	1,441
Visitor Vehicles	14,768	13,514	558	200,087
Headquarters Vehicles	52	49	2	704
Jamaica Bay Unit	**40,644**	**55,914**	**864**	**528,591**
Park-Owned Vehicles	87	111	3	968
Park-Leased Vehicles	920	1,602	18	14,231
Visitor Vehicles	37,036	50,161	793	477,109
Park Police Vehicles	2,600	4,041	51	36,284
Sandy Hook Unit	**28,006**	**22,342**	**951**	**394,960**
Park-Owned Vehicles	709	242	10	2,664
Park-Leased Vehicles	466	394	23	5,722
Visitor Vehicles	26,831	21,706	907	386,574

Note: Totals may not sum due to independent rounding.

Methodology

Highway mobile emissions depend on the number and type of vehicles that circulate within the paved road network in the park. Information was collected about the characteristics of each of the fleets identified at Gateway—park-owned, park-leased, visitor vehicles for all three units in the park, and Headquarters in the Staten Island Unit and Park Police in the Jamaica Bay Unit. The specific information requested included the number of vehicles circulating in the park for each of the vehicle fleets, the number of miles driven for each of the vehicles, the vehicle type (light-duty gas vehicle, light-duty diesel vehicle, light-duty gas truck, light-duty diesel truck, heavy-duty gas vehicle, and heavy-duty diesel vehicle), the age distribution of the fleet, and the miles of roads in the park. These data are provided under the data sources section. Because park personnel were unable to distinguish fuel type (gasoline versus diesel) in the park-owned vehicles (as provided by Demers 2003 and Clardy 2003 for all units), we allocated the vehicle miles traveled for those combined vehicle types using national defaults (EPA 2003). Visitor vehicles were assumed to fall into the light-duty vehicle category and were allocated by fuel type based on national default data.

With the information collected, Vehicle Miles Traveled (VMT) were estimated for each of the fleets in each unit. Ideally, VMT is an estimate of miles traveled by a given amount of vehicles for a given section of road. For example, for any of the park units, the average number of vehicles circulating on a given rural or arterial road should be counted and then multiplied by the length in miles of that section of road to obtain a good estimate of VMT for that road.

Because none of the park units were able to provide such an estimate, we used the annual miles accumulated by vehicle type provided for park-owned, park-leased, Headquarters, and Park Police vehicles. Where accumulated mileage was not available and number of vehicles was provided instead, the number of vehicles was multiplied by twice the total miles of roads in the corresponding park unit to account for an average round trip, and by 365 to generate annual VMT. We followed the same procedure for estimating VMT for visitor vehicles, but assumed only one day's worth of travel. VMT estimates are provided in Table 3.3-3. Please note that this methodology assumes that vehicles traveled the entire road distance within the park unit on a given day. This is due to the difficulty in characterizing the general routes driven by park and visitor vehicles in each unit, particularly for the Staten Island and Jamaica Bay units where there are various entrances into the park. However, because it is unlikely that vehicles drove on all roads in a unit, these VMT estimates reflect the upper bound in terms of miles that could have been traveled during the inventoried years.

Once the VMT estimates by vehicle type were obtained, we used EPA's Mobile 6.2 model to obtain emission factors for highway mobile vehicles (EPA 2002). In order to run Mobile 6.2, we needed to construct input files including park specific information: seasonal temperatures, absolute humidity, fleet information (e.g., VMT fractions, age distribution, mileage accumulation rages), fuel programs (e.g., oxygenated fuels), etc. This was done using the Mobile 6.2 input file developed for other National Park Service air emission inventories as a template (CE-CERT 2000). This input file was prepared for a number of parks throughout the country and contained the necessary setup and some default values that also applied to Gateway. The required VMT fraction inputs for the Mobile 6.2 model were calculated for each of the fleets by calculating the fraction of VMT for each of the vehicle types in each fleet. For example for the vehicle type LDGV in a given fleet, the VMT fraction was calculated as the VMT of that vehicle type divided by the sum of the VMT of all the vehicles in that fleet. Please refer to the Mobile 6.2 documentation for more information at www.epa.gov/otaq/m6.htm (EPA 2002). Unit specific characteristics, such as minimum and maximum temperatures, absolute humidity, and refueling program information were also introduced into the model (Weather.com 2003, ExxonMobil 2002). NPS age distribution was used for Staten Island and Sandy Hook (CE-CERT 2000). The Jamaica Bay Unit provided age distribution estimates that were used for that unit only[13] (Clardy 2003, Demers 2003). See the data sources section for these age distributions. National averages were used for the mileage accumulation rates (EPA 2003).

The Mobile 6.2 model produced emission factors in grams per mile for each of 28 vehicle types that can be combined into 8 major vehicle types (gasoline and diesel light duty vehicles, gasoline light duty trucks 1 and 2 and diesel light duty trucks, gasoline and diesel heavy duty trucks and motorcycles).

To obtain the final CAP emissions estimates from this source, the VMT numbers for each vehicle type and each fleet were multiplied by the corresponding emission factor from Mobile 6.2, and converted to emissions in lbs/year by multiplying by 1.102×10^{-6} short tons/lbs and by 2000 lbs/short ton.

[13] Jamaica Bay park personnel specifically indicated that this unit's vehicle age distribution should not be used for the other two park units (Demers 2003).

Table 3.3-3: VMT by Park Unit

Vehicle Type	Staten Island	Jamaica Bay	Sandy Hook
Total VMT	**8,624,877**	**12,070,527**	**14,381,398**
Park-Owned Vehicles	**22,710**	**13,460**	**110,926**
Light-Duty Gasoline Vehicles (LDGV)	NA	4,464	4,609
Light-Duty Gasoline Trucks (LDGT)	10,755	5,439	33,537
Heavy-Duty Gasoline Vehicles (HDGV)	3,388	2,644	53,766
Light-Duty Diesel Vehicles (LDDV)	NA	4	NA
Light-Duty Diesel Trucks (LDDT)	1,792	NA	5,589
Heavy-Duty Diesel Vehicles (HDDV)	6,775	909	13,425
Motorcycles	NA	NA	NA
Park-Leased Vehicles	**49,823**	**198,568**	**197,712**
Light-Duty Gasoline Vehicles (LDGV)	NA	79,991	115,972
Light-Duty Gasoline Trucks (LDGT)	37,367	104,310	68,256
Heavy-Duty Gasoline Vehicles (HDGV)	12,456	7,637	NA
Light-Duty Diesel Vehicles (LDDV)	NA	NA	104
Light-Duty Diesel Trucks (LDDT)	NA	NA	13,380
Heavy-Duty Diesel Vehicles (HDDV)	NA	6,630	NA
Motorcycles	NA	NA	NA
Visitor Vehicles	**8,552,355**	**11,858,499**	**14,072,760**
Light-Duty Gasoline Vehicles (LDGV)	8,543,456	11,847,207	14,029,990
Light-Duty Gasoline Trucks (LDGT)	NA	NA	NA
Heavy-Duty Gasoline Vehicles (HDGV)	47	24	1,187
Light-Duty Diesel Vehicles (LDDV)	7,696	10,672	12,638
Light-Duty Diesel Trucks (LDDT)	NA	NA	NA
Heavy-Duty Diesel Vehicles (HDDV)	1,156	596	28,945
Motorcycles	NA	NA	NA
Headquarters Vehicles	**24,911**	NA	NA
Light-Duty Gasoline Vehicles (LDGV)	6,228	NA	NA
Light-Duty Gasoline Trucks (LDGT)	18,683	NA	NA
Heavy-Duty Gasoline Vehicles (HDGV)	NA	NA	NA
Light-Duty Diesel Vehicles (LDDV)	NA	NA	NA
Light-Duty Diesel Trucks (LDDT)	NA	NA	NA
Heavy-Duty Diesel Vehicles (HDDV)	NA	NA	NA
Motorcycles	NA	NA	NA
Park Police Vehicles	NA	**740,568**	NA
Light-Duty Gasoline Vehicles (LDGV)	NA	547,236	NA
Light-Duty Gasoline Trucks (LDGT)	NA	193,332	NA
Heavy-Duty Gasoline Vehicles (HDGV)	NA	NA	NA
Light-Duty Diesel Vehicles (LDDV)	NA	NA	NA
Light-Duty Diesel Trucks (LDDT)	NA	NA	NA
Heavy-Duty Diesel Vehicles (HDDV)	NA	NA	NA
Motorcycles	NA	NA	NA

Source: VMT calculated using data provided by Demers 2003, Clardy 2003, Dexter 2003, Natural Resources 2003, HQ Property Office 2003, Piccolo 2003, Hansen 2003, Barthell 2003, Lancos 2003, and Robinson 2003.
Note: NA = Not applicable.

Data Sources

The fleet information provided by the park units is provided in Table 3.3-4. Vehicle miles traveled for all park units were provided by Cal Clardy and Alixandra Demers (2003). The number of park-owned and leased vehicles by vehicle type for Staten Island were provided by Natural Resources personnel and John Dexter (2003). Park Police vehicle numbers and mileage information were provided by John Piccolo (2003). The Headquarters Property Office provided park-leased vehicle mileage by vehicle type for the Jamaica Bay Unit (2003). The number of Sandy Hook park-owned vehicles by vehicle type were provided by Louis Hansen (2003). Wayne Barthell of GSA provided vehicle numbers and mileage information for leased vehicles at Sandy Hook (2003). The number of visitor vehicles entering each park unit was provided by John Lancos (2003). Because the distance of road miles within each park unit were not provided by Gateway, with the exception of the Miller Field road distance provided by Earnestine Robinson (2003), we measured road distances for each unit on Gateway maps. Vehicle age distributions used for the Jamaica Bay Unit are provided in Table 3.3-5 and for the Staten Island and Sandy Hook units in Table 3.3-6.

Table 3.3-4: Fleet information (# of Vehicles/Accumulated Miles) Provided by Park Unit

Vehicle Category and Type	Staten Island[14]		Jamaica Bay		Sandy Hook	
	# of Vehicles	Miles Traveled	# of Vehicles	Miles Traveled	# of Vehicles	Miles Traveled
Park-Owned Vehicles						
Light-Duty Gasoline Vehicles (LDGV)	0			4,402	4	4,609
Light-Duty Gasoline Trucks (LDGT)	18	10,755		5,421	18	33,537
Heavy-Duty Gasoline Vehicles (HDGV)	3	3,388		2,463	4	22,397
Light-Duty Diesel Vehicles (LDDV)	0			66	0	
Light-Duty Diesel Trucks (LDDT)	3	1,792		18	3	5,589
Heavy-Duty Diesel Vehicles (HDDV)	6	6,775		1,090	8	44,794
Park-Leased Vehicles						
Light-Duty Gasoline Vehicles (LDGV)				79,991	6	116,076
Light-Duty Gasoline Trucks (LDGT)	6			104,310	10	68,256
Heavy-Duty Gasoline Vehicles (HDGV)	2			14,267		
Light-Duty Diesel Vehicles (LDDV)						
Light-Duty Diesel Trucks (LDDT)					2	13,380
Heavy-Duty Diesel Vehicles (HDDV)						
Visitor Vehicles						
Light-Duty Gasoline Vehicles (LDGV)	1,528,800		1,907,513		779,286	
Light-Duty Diesel Vehicles (LDDV)	2,146		2,103		860	
Buses (HDDB)	401		155		1,674	
Headquarters Vehicles						
Light-Duty Gasoline Vehicles (LDGV)	1		NA	NA	NA	NA
Light-Duty Gasoline Trucks (LDGT)	3		NA	NA	NA	NA
Heavy-Duty Gasoline Vehicles (HDGV)			NA	NA	NA	NA
Light-Duty Diesel Vehicles (LDDV)			NA	NA	NA	NA
Light-Duty Diesel Trucks (LDDT)			NA	NA	NA	NA
Heavy-Duty Diesel Vehicles (HDDV)			NA	NA	NA	NA
Park Police						
Light-Duty Gasoline Vehicles (LDGV)	NA	NA		547,236	NA	NA
Light-Duty Gasoline Trucks (LDGT)	NA	NA		193,332	NA	NA
Heavy-Duty Gasoline Vehicles (HDGV)	NA	NA			NA	NA
Light-Duty Diesel Vehicles (LDDV)	NA	NA			NA	NA
Light-Duty Diesel Trucks (LDDT)	NA	NA			NA	NA
Heavy-Duty Diesel Vehicles (HDDV)	NA	NA			NA	NA

Source: Demers 2003, Clardy 2003, Dexter 2003, Natural Resources 2003, HQ Property Office 2003, Piccolo 2003, Hansen 2003, Barthell 2003, Lancos 2003, and Robinson 2003.
Note: NA = Not applicable. Blanks cells indicate that no data were provided.

[14] Staten Island gasoline vehicle totals include duel fuel compressed natural gas (CNG) vehicles because adequate data were not available on the proportion of time that CNG was used versus gasoline.

Table 3.3-5: Vehicle Age Distribution for the Jamaica Bay Unit

Vehicle Model Year	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
2002	10.6%	4.8%	0.0%	7.5%	0.0%	0.0%	19.4%
2001	20.2%	0.0%	0.0%	9.5%	0.0%	0.0%	21.2%
2000	0.0%	12.6%	0.0%	9.0%	0.0%	0.0%	15.8%
1999	0.0%	3.9%	0.0%	8.6%	0.0%	0.0%	11.8%
1998	8.7%	11.1%	0.0%	8.1%	0.0%	0.0%	8.8%
1997	0.0%	10.4%	0.0%	7.7%	0.0%	0.0%	6.4%
1996	0.0%	0.0%	0.0%	7.2%	0.0%	0.0%	4.6%
1995	7.5%	3.0%	6.8%	6.7%	0.0%	0.0%	3.3%
1994	14.2%	5.6%	0.0%	6.2%	0.0%	0.0%	2.3%
1993	0.0%	2.6%	11.9%	5.6%	0.0%	0.0%	1.6%
1992	12.8%	0.0%	0.0%	5.0%	0.0%	0.0%	1.1%
1991	6.1%	0.0%	0.0%	4.4%	0.0%	25.7%	3.7%
1990	5.8%	0.0%	0.0%	3.5%	0.0%	23.5%	0.0%
1989	0.0%	24.7%	55.0%	2.7%	0.0%	0.0%	0.0%
1988	5.2%	8.7%	0.0%	2.0%	0.0%	0.0%	0.0%
1987	0.0%	1.6%	0.0%	1.5%	0.0%	0.0%	0.0%
1986	4.7%	0.0%	3.8%	1.1%	47.8%	0.0%	0.0%
1985	0.0%	4.0%	0.0%	0.9%	0.0%	0.0%	0.0%
1984	4.3%	1.2%	6.6%	0.6%	40.2%	0.0%	0.0%
1983	0.0%	1.1%	6.2%	0.5%	0.0%	0.0%	0.0%
1982	0.0%	4.0%	0.0%	0.4%	0.0%	0.0%	0.0%
1981	0.0%	0.0%	0.0%	0.3%	0.0%	10.5%	0.0%
1980	0.0%	0.0%	5.1%	0.2%	0.0%	0.0%	0.0%
1979	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%
1978	0.0%	0.7%	0.0%	0.4%	12.0%	32.3%	0.0%
1977	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1976	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1975	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.0%
1974	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1973	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1972	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.0%
1971	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1970	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1969	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1968	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1967	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1966	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1965	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1964	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1963	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1962	0.0%	0.0%	0.0%	0.0%	0.0%	8.1%	0.0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Clardy 2003; Demers 2003.

Note: These categories include: LDGV: Light-Duty Gas Vehicles; LDGT: Light-Duty Gas Trucks; HDGV: Heavy-Duty Gas Vehicles; LDDV: Light-Duty Diesel Vehicles; LDDT: Light-Duty Diesel Trucks; HDDV: Heavy-Duty Diesel Vehicles; and MC: Motorcycles.

Table 3.3-6: National Parks Study Vehicle Age Distribution used for Sandy Hook and Staten Island units by Mobile 6.2 vehicle classes (see below for description)

Vehicle Model Year	LDV	LDT1	LDT2	LDT3	LDT4	HDV2b	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
2001	15.8%	16.1%	16.1%	0.0%	0.0%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	14.7%	10.0%
2000	15.8%	16.1%	16.1%	22.8%	22.8%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	14.7%	10.0%
1999	15.8%	16.1%	16.1%	22.8%	22.8%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	14.7%	10.0%
1998	15.8%	16.1%	16.1%	22.8%	22.8%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	16.63%	14.7%	10.0%
1997	5.9%	4.3%	4.3%	4.9%	4.9%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	8.8%	10.0%
1996	5.9%	4.3%	4.3%	4.9%	4.9%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	8.8%	10.0%
1995	5.9%	4.3%	4.3%	4.9%	4.9%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	8.8%	10.0%
1994	5.9%	4.3%	4.3%	4.9%	4.9%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	6.77%	8.8%	10.0%
1993	2.5%	2.5%	2.5%	2.6%	2.6%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.0%	5.0%
1992	2.5%	2.5%	2.5%	2.6%	2.6%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.0%	5.0%
1991	2.5%	2.5%	2.5%	2.6%	2.6%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.11%	2.0%	5.0%
1990	1.0%	1.8%	1.8%	1.1%	1.1%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.0%	5.0%
1989	1.0%	1.8%	1.8%	1.1%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1988	1.0%	1.8%	1.8%	1.1%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1987	0.4%	1.0%	1.0%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1986	0.4%	1.0%	1.0%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1985	0.4%	1.0%	1.0%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1984	0.4%	1.0%	1.0%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1983	0.4%	0.4%	0.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1982	0.2%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1981	0.2%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1980	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1979	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1978	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1977	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: CE-CERT 2000.
Note: These categories refer to Mobile 6.2 vehicle classes:
LDV: Light-Duty Vehicles (passenger cars); LDT1: Light-Duty Trucks 1 (0-6,000 lbs. Gross Vehicle Weight Rating (GVWR), 0-3,750 lbs. Loaded Vehicle Weight (LVW));
LDT2: Light-Duty Trucks 2 (0-6,000 lbs. GVWR, 3,751-5,750 lbs. LVW); LDT3: Light-Duty Trucks 3 (6,001-8,500 lbs. GVWR, 0-5,750 lbs. Alternative LVW);
LDT4: Light-Duty Trucks 4 (6,001-8,500 lbs. GVWR, 5,751 lbs and greater ALVW); HDV2b: Class 2b Heavy-Duty Vehicles (8,501-10,000 lbs. GVWR);
HDV3: Class 3 Heavy-Duty Vehicles (10,001-14,000 lbs. GVWR); HDV4: Class 4 Heavy-Duty Vehicles (14,001-16,000 lbs. GVWR);
DV5: Class 5 Heavy-Duty Vehicles (16,001-19,500 lbs. GVWR); HDV6: Class 6 Heavy Duty Vehicles (19,501-26,000 lbs. GVWR);
HDV7: Class 7 Heavy Duty Vehicles (26,001-33,000 lbs. GVWR); HDV8a: Class 8a Heavy-Duty Vehicles (33,001-60,000 LBS. GVWR);
HDV8b: Class 8b Heavy-Duty Vehicles (>60,000 lbs. GVWR); HDBS: School Buses; HDBT: Transit and Urban Buses; MC: Motorcycles.

Table 3.3-7 presents the sources of activity data and emission factors used in the CAP emission calculations for mobile highway sources in this inventory.

Table 3.3-7: Data Sources for CAP Emission Estimates of Mobile Highway Sources

Source/Park Unit	Data Source
All Units	
Mobile 6.2 Model	EPA, 2002.
Seasonal Temperatures and Relative Humidity	Weather.com, 2003.
Refueling Program Information	ExxonMobil, 2002.
VMT for park-owned vehicles	Clardy, 2003; Demers, 2003.
Visitor vehicle numbers	Lancos, 2003.
National defaults for vehicle classes	EPA, 2003.
Staten Island Unit	
Vehicle Age Distribution	CE-CERT, 2000.
Park Fleet Characteristics (No. Vehicles/Miles)	Dexter, 2003.
Park-leased vehicle data	Natural Resources, 2003.
Miller Field road miles	Robinson, 2003.
Jamaica Bay Unit	
VMT for park-owned vehicles, Vehicle Age Distribution	Clardy, 2003; Demers, 2003.
Park Police vehicle data	Piccolo, 2003.
Park-leased vehicle data	HQ Property Office, 2003.
Sandy Hook Unit	
Vehicle Age Distribution	NPS, 2001.
Park-leased vehicle data	Barthell, 2003.

3.3.2 Nonroad Vehicles

Results

Nonroad vehicles contributing to CAP emissions at Gateway included nonroad equipment and other vehicles and marine boats. CAP emissions of NO_x, VOCs, PM, and CO were emitted from these sources. The Jamaica Bay Unit accounted for the largest share of CAP nonroad emissions: 53 percent of NO_x, 80 percent of VOCs, 79 percent of PM, and 79 percent of CO. This is due to the inclusion of higher horsepower Park Police patrol boats. Sandy Hook's nonroad emissions are noticeably lower because Sandy Hook only has two park boats. Table 3.3-8 summarizes each park unit's non-highway CAP emissions.

Table 3.3-8: Gateway Summary of Nonroad CAP Emissions

	Emissions (lbs)			
	NO_x	VOCs[a]	PM	CO
Nonroad Vehicles and Other Equipment	**2,953**	**757**	**744**	**1,666**
Staten Island Unit	1,537	287	309	838
Jamaica Bay Unit	639	188	208	410
Sandy Hook Unit	777	282	227	418
Marine Boats and Vessels	**3,897**	**359,885**	**23,783**	**724,336**
Staten Island Unit	920	69,935	4,601	147,636
Park-owned	*455*	*44,535*	*2,947*	*88,495*
Visitor	*NE*	*NE*	*NE*	*NE*
Headquarters	*464*	*25,401*	*1,655*	*59,141*
Jamaica Bay Unit	2,969	289,101	19,126	575,013
Park-owned	*213*	*19,617*	*1,296*	*39,518*
Visitor	*NE*	*NE*	*NE*	*NE*
Park Police	*2,756*	*269,484*	*17,830*	*535,495*
Sandy Hook Unit	9	849	56	1,686
Park-owned	*9*	*849*	*56*	*1,686*
Visitor	*NE*	*NE*	*NE*	*NE*
Total Nonroad Vehicles	**6,850**	**360,641**	**24,528**	**726,001**
Staten Island Unit	2,456	70,222	4,910	148,474
Jamaica Bay Unit	3,608	289,289	19,334	575,423
Sandy Hook Unit	786	1,130	283	2,104

Note: NA = Not applicable. NE = Not estimated.
[a] Includes HC emissions from marine boats and vessels.

Methodology

Nonroad Equipment

CAP emissions were estimated using nonroad vehicle and equipment-specific data provided by each park unit. The number and type of each vehicle and piece of equipment reported by the Gateway units are provided in the data sources section. The horsepower (hp) and operating hour information for each vehicle/equipment type were also requested from Gateway.

In order to estimate CAPs from nonroad vehicles and other equipment, the number of each vehicle type was multiplied by the corresponding horsepower (hp), load factor, operating hours per year, and emission factor (gm/hp-hr) for that vehicle/equipment type. Because the Sandy Hook Unit was the only unit able to provide annual operating hours for some of the equipment (i.e., agriculture tractors and mowers), and none of the units provided specific hp information, we made a number of assumptions. Operating hours provided for mowers from Sandy Hook were used for mowers in the other units, operating hours for similar equipment present in other NPS air emission inventories for other parks (i.e., Grand Canyon and Chiricahua) were assumed for Gateway (NPS 2002, NPS 2003). We assumed 100 hours of operation for all other equipment. Emission factors and load factors for each equipment type were obtained from EPA's Nonroad Model data sets and NPS air emission inventories for other parks (EPA 2000, NPS 2002, NPS 2003). Table 3.3-9 provides the nonroad vehicle and equipment emissions factors and load factors used in the CAP calculations.

Table 3.3-9: Nonroad Vehicle and Equipment Emission Factors

Vehicle Type	Emission Factors (gm/hp-hr)				Load Factor
	NO_x	VOC	PM	CO	
Tractors	1.00	0.88	0.61	0.42	0.55
Backhoe	1.02	2.19	1.96	2.32	0.55
Lawn Mowers	10.30	1.30	1.11	4.80	0.55
Riding Mowers	10.30	1.30	1.11	4.80	0.64
Dozer	0.99	0.92	1.17	1.27	0.59
Grader	9.60	1.43	1.06	3.80	0.61
Air Compressor	0.90	1.30	3.99	4.80	0.48
Sweeper	14.00	1.46	1.70	6.06	0.68
Chainsaws	0.96	1.30	3.60	4.80	0.60
Trimmer/Edger	0.90	1.30	3.99	4.80	0.43
Forklift	9.60	1.43	1.06	3.80	0.30
Front End Loader	10.30	1.30	1.11	4.80	0.62
Diesel Off-highway Trucks	1.03	2.19	2.04	2.31	0.57
ATV	1.03	2.19	2.04	2.31	0.34

Source: EPA 2000; NPS 2002; NPS 2003.

Emissions in grams for each CAP (NO_x, VOC, PM, and CO) and vehicle/equipment type were then converted to lbs of gas by multiplying by 0.00205 lbs/gram. These emissions for each vehicle/equipment type were then summed by gas to obtain total emissions by gas for all nonroad vehicles and equipment at each park unit.

Marine Boats

Boat use is a significant part of mobile activities at Gateway. All three park units are located along shoreline, which includes expansive bays and open waterways. Recreational boating dominates most of the water activity at the park. There are also park-owned and Headquarters water vessels and Park Police patrol boats. We aimed to calculate CAP emissions for park-owned and visitor-owned boats for the three units, and for Headquarters and Park Police. Data provided by the park on these sources is presented in the data sources section below. For each boat category for each park unit, the number of engines in each boat was multiplied by the engine power (hp), the hours of operation per year, the load factor of 0.21, and the corresponding emission factor for each CAP. The emission factors are provided in Table 3.3-10.

Table 3.3-10: Marine Boats and Vessels Emission Factors

Engine Type/Units	Emission Factors				
	SO_2	NO_x	PM	CO	HC
Diesel Engine (g/hp-hr) (lb/hp-hr)	 0.352 0.001	 8.92 0.020	 0.563 0.001	 1.91 0.004	 1.26 0.003
2-Stroke Gasoline Engine (g/hp-hr) (lb/hp-hr)	 NA NA	 1.19 0.003	 7.7 0.017	 231.26 0.510	 116.38 0.257
4-Stroke Gasoline Engine (g/hp-hr) (lb/hp-hr)	 NA NA	 7.46 0.016	 0.06 0.0001	 339.18 0.748	 14.92 0.033

Note: NA = Not applicable.
Source: EPA 2000.

Emissions were estimated for park-owned boats at each Gateway unit and for Headquarters at the Staten Island Unit and Park Police at the Jamaica Bay Unit. We were unable to estimate visitor boat emissions, which comprises a large share of the park's boating activity, because sufficient data were not provided by the park. Jamaica Bay park personnel did provided some information on visitor boat use in 2002; however, these data were inadequate to allow for estimation of actual or even potential emissions.

As an alternate approach to provide a context for evaluating potential emissions from Gateway's visitor boats, we looked at the emissions from each of the counties in this area. The Staten Island Unit is located in Richmond County; the Jamaica Bay Unit crosses both Kings County (Brooklyn) and Queens County; and the Sandy Hook Unit is located in Monmouth County. EPA's *National Emissions Inventory (NEI)* provides county-level emissions disaggregated by source category and fuel type for the 1999 base year (EPA 2002). These emissions were developed using EPA's Nonroad model.

Table 3.3-11 provides the data obtained from NEI for the counties bordering Gateway.

Table 3.3-11: County Level Emissions from Recreational Boats by Fuel in 1999

Park Unit/County/Fuel	Emissions (tons/yr)				
	SO_2	NOx	VOC	PM	CO
Richmond County (Staten Island)[a]					
Gasoline	0.2	2.7	71.9	3.6	175.3
Diesel	0.2	1.6	0.1	0.1	0.3
Kings County (Brooklyn)[b]					
Gasoline	0.4	7.0	129.0	6.4	373.6
Diesel	0.7	5.0	0.2	0.1	0.8
Queens County[b]					
Gasoline	1.1	17.9	352.5	17.5	987.5
Diesel	1.7	12.2	0.5	0.4	2.0
Monmouth County[c]					
Gasoline	0.8	10.4	286.8	14.5	685.6
Diesel	0.8	5.7	0.2	0.2	0.9

Source: EPA 2002.
[a] The Staten Island Unit is located in Richmond County.
[b] The Jamaica Bay Unit is located in Kings and Queens counties.
[c] The Sandy Hook Unit is located in Monmouth County.

Using a top-down approach, it would be ideal to apportion these county-level estimates to Gateway's visitor boats. Unfortunately there is not a feasible way to carry-out such an apportionment without making gross assumptions about visitor boat routes or the number of visitor boats per length of shoreline. The nature of the waterways surrounding Gateway make it difficult to approximate emissions without more data on park-related boating activity. The estuary between the Staten Island and Jamaica Bay units in New York and the Sandy Hook Unit in New Jersey opens up to the Atlantic and makes it difficult to distinguish between the number of boats traveling in this area that are "park visitors". Additionally, there are many miles of shoreline in this area that not within park boundaries, including shoreline along the Upper and Lower Bays. Finally, estimating visitor boat emissions was further complicated by the difficulty in obtaining information from concessionaires, such as the Great Kills Park Marina. These county estimates offer an upper bound of emissions.

Initially we attempted to quantify park emissions using the limited data we received from Jamaica Bay on visitor boat activity. We estimated these emissions using a bottom-up approach. When these "bottom-up" estimates were compared to the sum of the emissions from Kings and Queens counties, Jamaica Bay's emissions ranged from 29 percent of NO_x emissions for the counties and 144 percent of PM emissions for the counties. These inconsistencies led to the exclusion of visitor boats from Gateway CAP emission totals. These discrepancies could be due to poor data on visitor boat use at Jamaica Bay or to uncertainties in the development of the county estimates.

Data Sources

Data on the number and type of nonroad vehicles and equipment provided by Gateway personnel are provided in Table 3.3-12. Marine boat and vessel data provided by the park units are provided in Table 3.3-13. The emission factors and load factors used in the nonroad calculations were obtained from EPA's *Nonroad Emissions Database* (EPA 2000). County-level emissions data for recreational boats in 1999 were obtained from EPA's *National Emissions Inventory* (2002).

Table 3.3-14 presents the sources of activity data and emission factors used in the CAP emission calculations for nonroad sources in this inventory.

Table 3.3-12: Nonroad Vehicles & Other Equipment Data

Nonroad Vehicle or Equipment Type	Staten Island	Jamaica Bay	Sandy Hook
	# of Vehicles or Units		
Mowers	18	18	17
Small Mower			*1*
Push Mowers	*10*		*12*
Ride Mower	*8*		*4*
Trimmers	28	8	
Weed Wackers	*24*		
Edgers	*4*		
Tractors	5	4	11
Ag Tractors			*6*
Lawn Tractors			*5*
Backhoes	1	1	2
Graders	1		1
Chainsaws	10	12	
Compressors	3		2
Sweepers	1	1	
Forklifts	3	1	1
Loaders	1	1	2
Dozers		1	3
Bobcat		1	
Diesel pickups		4	
Roller			1
Recycler			1
Ride-around Trash Compactor			1
Trash Compactor (load and pack)			1
Cement Mixer			1
Trencher - construction equipment			1
Small campers – construction equipment			6
ATVs			4
Scooters			2
Other equipment			1

Source: Dexter 2003; Clardy 2003; Fowler 2003.

Table 3.3-13: Data on Boats

Park Unit/Source	Engine Type (2 or 4 stroke)	Average # of engines[a]	Engine power (hp)	Hours of Operation/ year
Staten Island Unit				
Park-owned				
20-foot Boat	2	1.6	150	2,520
Rubber Boat	2	1.6	45	2,520
Float Boat	2	1.6	10	2,520
Visitor-owned	NAV	NAV	NAV	NAV
Headquarters				
Outboard Motor (Zodiac)	4	1.6	9.9	2,520
Outboard Motor (Trolling)	2	1.6	115	2,520
Inboard Motor (Rolling Vessel)	4	1.6	5.1	2,520
Jamaica Bay Unit				
Park-owned				
Motor Boat	2	2	60	3,018
Barge	2	0	0	0
Chase Boat	2	1	10	144
Sail Boat/Canoe	0	0	0	144
JBU Wildlife Refuge Motor Boat	4	1	50	75
Visitor-owned [b]	NAV	NAV	NAV	NAV
Park Police				
34 Foot Aluminum Patrol Boat	2	1.6	370	1,000
27 Foot Boston Whaler	2	1.6	250	600
41 Foot Aluminum Patrol Boat	2	1.6	480	1,200
25 Foot Sea Ark Aluminum Patrol Boat	2	1.6	150	1,000
44 Foot Sea Ark	2	1.6	590	2,000
38 Foot Bertram Patrol Boat	2	1.6	350	2,000
Sandy Hook Unit				
Park-owned				
Outboard Gas Boat	2	1	115	50
Outboard Gas Boat	2	1	200	50
Visitor-owned	NAV	NAV	NAV	NAV

Sources: Staten Island data from Dexter 2003; and Ringenary 2003. Staten Island park-owned vehicle hp based on average engine power for corresponding vehicles. Staten Island park-owned vehicle operating hours assumed for HQ operating hours were data unavailable from park personnel.
Jamaica Bay data from McCarthy 2003; Olijnyk 2003; and Arthur 2003.
Sandy Hook data from Fowler 2003.
[a] An average of 1.6 was used where data not provided by park unit.
[b] Jamaica Bay did provide some data on visitor-owned boats, but data were inadequate for estimation.

Table 3.3-14: Data Sources for Estimation of CAP Emissions from Mobile Nonroad Sources

Source/Park Unit	Data Source
All Units	
Nonroad vehicle/equipment and marine boat emissions factors	EPA, 2000; NPS, 2002; NPS, 2003.
Nonroad vehicle/equipment operating hour information for certain equipment	NPS, 2002; NPS, 2003.
Load factors	EPA, 2000.
County-level recreational boat emissions	EPA, 2002
Staten Island Unit	
Nonroad vehicle/equipment information	Dexter, 2003.
Park-owned boat information	Dexter, 2003.
Headquarters boat information	Ringenary, 2003.
Jamaica Bay Unit	
Nonroad vehicle/equipment information	Clardy, 2003.
Park-owned and visitor-owned boat information	McCarthy, 2003; Olijnyk, 2003.
Park Police boat information	Arthur, 2003.
Sandy Hook Unit	
Nonroad vehicle/equipment information and boat information	Fowler, 2003.

4 GREENHOUSE GAS EMISSIONS

This section addresses greenhouse gas (GHG) emissions from Gateway National Recreation Area. GHGs warm the surface of the earth by absorbing some of the solar radiation that would otherwise be radiated to space. For billions of years, this warming—known as the "greenhouse effect"–-has kept surface temperatures warm enough to sustain life. Naturally occurring GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor, and ozone (O_3).

Since the Industrial Revolution, human activities (e.g., fuel combustion in stationary and mobile sources, agriculture, and waste generation) have caused an increase in the concentration of these gases. In addition, human activities have produced emissions of several GHGs that do not occur naturally in the atmosphere, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) – collectively referred to as high-GWP gases. Human contributions of greenhouse gases have led to an enhanced greenhouse effect, which is in turn changing the earth's climate.

Since there are numerous types of GHGs, each with distinct properties, a means to compare emissions of different GHGs is necessary. The global warming potential (GWP) is a measure that quantifies the relative radiative forcing impacts of various GHGs. It is defined as the cumulative radiative forcing—both direct and indirect effects—over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas, here CO_2 (IPCC 2001). GWP-weighted emissions are expressed in metric tons of carbon equivalent (MTCE). The weight ratio of molecular carbon to CO_2 is 12/44. In order to convert emissions reported in metric tons of a gas to MTCE, the following equation is used:

$$MTCE = (MT\ of\ gas) \times (GWP) \times (12/44)$$

GWP values allow policy makers to compare the impacts of emissions and reductions of different gases. See Figure 2.3-1 in the Introduction (Chapter 1) for a list of GHGs and their associated GWPs.

We estimated emissions from the following GHG sources at Gateway: CO_2 from fossil fuel combustion; CH_4 and N_2O from stationary combustion; CH_4 and N_2O from mobile combustion; high-GWPs from refrigeration and air conditioning; N_2O from fertilizer use; CH_4 from landfilled waste; and CH_4 and N_2O from wastewater. The following sections provide the results, methodology, and data sources used in the calculation of GHG emissions from these sources for each park unit: Staten Island, Jamaica Bay, and Sandy Hook.

4.1 CO_2 FROM FOSSIL FUEL COMBUSTION

CO_2 emissions from fossil fuel combustion comprised nearly 93 percent of total GHG emissions from Gateway National Recreation Area. Total emissions from this source were 7,648 MTCE. Emissions from stationary and mobile fuel combustion within park boundaries (i.e., direct emissions) accounted for 75 percent or 5,702 MTCE, and emissions from electricity purchased from a utility (i.e., indirect emissions) accounted for 25 percent or 1,946 MTCE. Of the total CO_2 emissions from this source, the Staten Island, Jamaica Bay, and Sandy Hook units accounted for 37, 38, and 26 percent, respectively. CO_2 emissions from fossil fuel combustion at Sandy Hook were considerably lower than the other units because Sandy Hook purchases more than four times less electricity. Table 4.1-1 provides a summary of direct and indirect emissions by park unit. The sections that follow illustrate the results, methodology, and data sources for both direct and indirect emissions of CO_2 from fossil fuel combustion.

Table 4.1-1: Gateway Summary of CO_2 Emissions from Fossil Fuel Combustion

Source/Park Unit	Emissions (MTCE)
Direct Emissions: Fuel Combustion (including stationary and mobile)	**5,702**
Staten Island Unit	1,943
Jamaica Bay Unit	1,980
Sandy Hook Unit	1,779
Indirect Emissions: Purchased Electricity	**1,946**
Staten Island Unit	850
Jamaica Bay Unit	908
Sandy Hook Unit	187
Total Emissions	**7,648**
Staten Island Unit	**2,794**
Jamaica Bay Unit	**2,888**
Sandy Hook Unit	**1,967**

Note: Totals may not sum due to independent rounding.

4.1.1 Direct Emissions from Combustion (including stationary and mobile)

Results

Direct emissions from combustion include emissions associated with burning fuel (coal,[15] petroleum, or natural gas) to generate energy within park boundaries. Direct emissions from stationary and mobile fossil fuel combustion at Gateway were estimated at 5,702 MTCE. Of this total, the Staten Island Unit accounted for 34 percent, the Jamaica Bay unit accounted for 35 percent, and the Sandy Hook Unit accounted for 31 percent. Two end-use sectors for fossil fuel combustion were defined for Gateway: residential/commercial and transportation (industrial end-uses were not supported at Gateway). Transportation contributed the majority (71 percent) of CO_2 emissions as compared to residential/commercial activities, which accounted for the remaining 29 percent.

Table 4.1-2 and Table 4.1-3 summarize each park unit's emissions within the residential/commercial and transportation end-use sectors, respectively. Transportation emissions are disaggregated into park-owned, park-leased, and visitor vehicles for each park unit, and into park-owned boats where data were available. Presenting emissions at this level of detail may serve as a helpful means for park personnel to better understand their unit-specific emission sources. Emissions from Headquarters are included under the Staten Island Unit, while emissions from Park Police activities are included under the Jamaica Bay Unit. Table 4.1-4 presents the total direct CO_2 emissions from fuel combustion for both sectors, totaled by park unit.

[15] Note that coal is not used at Gateway.

Table 4.1-2: Direct CO_2 Emissions from Fuel Combustion in the Residential/Commercial Sector

Source/Park Unit	Emissions (MTCE)
Natural Gas	**1,179**
Staten Island Unit	950
Jamaica Bay Unit	229
Sandy Hook Unit	NA
Petroleum	**450**
Staten Island Unit	21
Jamaica Bay Unit	225
Sandy Hook Unit	205
Total	**1,629**

Notes: NA = Not applicable because natural gas was not consumed at Sandy Hook.
Petroleum use in this sector refers to distillate fuel oil.
Totals may not sum due to independent rounding.

Table 4.1-3: Direct CO_2 Emissions from Fuel Combustion in the Transportation Sector

Source/Park Unit	Emissions (MTCE)
Staten Island Unit	**973**
Motor Gasoline	950
Park-owned, Park-leased, Headquarters Vehicles	16
Visitor Vehicles	934
Distillate Fuel Oil	22
Park-owned, Park-leased, Headquarters Vehicles	21
Visitor Vehicles	2
Jamaica Bay Unit	**1,526**
Motor Gasoline	1,493
Park-owned, Park-leased Vehicles	27
Park Police Vehicles	86
Visitor Vehicles	1,295
Park-owned Boats	84
Distillate Fuel Oil	33
Park-owned, Park-leased Vehicles	4
Visitor Vehicles	2
Park-owned Boats	27
Sandy Hook Unit	**1,575**
Motor Gasoline	1,551
Park-owned, Park-leased Vehicles	17
Visitor Vehicles	1,534
Distillate Fuel Oil	23
Park-owned, Park-leased Vehicles	8
Visitor Vehicles	15
Total	**4,073**

Notes: Totals may not sum due to independent rounding.

Table 4.1-4: Direct CO_2 Emissions from Fossil Fuel Combustion by Sector and Unit

Source/Park Unit	Emissions (MTCE)
Residential/Commercial	**1,629**
Staten Island Unit	971
Jamaica Bay Unit	454
Sandy Hook Unit	205
Transportation	**4,073**
Staten Island Unit	973
Jamaica Bay Unit	1,526
Sandy Hook Unit	1,575
Total	**5,702**

Note: Totals may not sum due to independent rounding.

Staten Island, followed by Jamaica Bay, accounted for the largest share of CO_2 emissions from fossil fuel combustion in the residential/commercial sector, while Jamaica Bay and Sandy Hook had nearly identical CO_2 emissions from transportation-related combustion. The variation in emissions across the park units may be attributed to a number of factors. Staten Island reported the highest amount of fuel consumed for building uses (e.g., heating), which could be due to the additional heating needs for Headquarters buildings located within this unit. Similarly, Jamaica Bay's totals include Park Police stationary CO_2 emissions, which added to its emission totals. On the other hand, the fuel-switch from distillate fuel oil to natural gas in some of the building heating equipment at Staten Island and at Jamaica Bay considerably reduced emissions at these units from what they would otherwise have been.

The Sandy Hook Unit's lower residential/commercial emissions relative to the two park units located in New York may indicate an underestimate of fuel consumed. Sandy Hook has not transitioned any of its equipment from using oil to natural gas, which would result in even lower CO_2 emissions. Given the use of oil, residential/commercial CO_2 emissions from this park unit were much lower than anticipated. Based on our site visit to Gateway, the number of buildings located on Sandy Hook would suggest that fuel use would be more comparable to that in the Staten Island and Jamaica Bay units.

The large number of visitor vehicles, particularly to the Sandy Hook and Jamaica Bay units, and their associated CO_2 emissions directly corresponds with the higher transportation CO_2 emissions. Jamaica Bay's transportation totals also include park-owned marine boats, which are not included in the Staten Island or Sandy Hook totals due to the lack of boat fuel consumption data.

Methodology

In order to estimate CO_2 emissions from fossil fuel combustion, fuel consumption data were requested from each Gateway park unit. The park units provided fuel consumption activity data for the residential/commercial end-use sector; however, transportation distillate and motor gasoline fuel use data received from Gateway were very limited or missing for certain vehicle types. This methodology aimed to include emissions for park-owned, park-leased, and visitor vehicles for all units, and Headquarters and Park Police vehicles for Staten Island Unit and Jamaica Bay Unit, respectively.

The methodology for estimating emissions from direct combustion utilizes the energy consumption of fuels and their corresponding carbon contents, maintaining consistency with EPA's

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001. Fuel consumption data in gallons, therms, or cubic feet were converted to energy units in British thermal units (Btu) using conversions and fuel-specific heat contents. The fuel consumption data provided by the park units for the residential/commercial sector and the fuel consumption estimates we developed for the transportation sector are provided in Table 4.1-5, Table 4.1-6, and Table 4.1-7, respectively, for each park unit.[16] The corresponding consumption in million Btu (MMBtu) is provided in the third column. Next, these values were multiplied by fuel-specific carbon content coefficients. The resulting net carbon content quantities in million metric tons of carbon for each fuel were multiplied by fuel-specific fraction oxidized factors, which refer to the percentages of carbon in fuels that reacts with oxygen in the air to become emissions. The resulting emissions in million metric tons of carbon were converted to MTCE by multiplying by 10^6 metric tons/million metric tons. See Table 4.1-8 for heat contents, carbon contents, and estimates of the fraction of carbon that oxidizes.

Table 4.1-5: Staten Island Fuel Consumption

Park Unit/Source	Fuel Consumption	Fuel Consumption (MMBtu)
Residential/Commercial		
Natural Gas	(therms)	
	666,000	66,000
Distillate Fuel Oil	(gallons)	
	7,500	1,040
Transportation		
Motor Gasoline	(gallons)	
Park-owned, Park-leased, Headquarters Vehicles	6,831	854
Visitor Vehicles	390,082	48,788
Marine Park-owned Boats	NAV	
Distillate Fuel Oil	(gallons)	
Park-owned, Park-leased, Headquarters Vehicles	7,500	1,040
Visitor Vehicles	549	76
Marine Park-owned Boats	NAV	

Notes: Residential/commercial fuel consumption provided by park units; transportation fuel consumption calculated as described under Methodology.
NAV = Not available.

[16] See data sources section for an explanation of how these estimates were developed.

Table 4.1-6: Jamaica Bay Fuel Consumption

Park Unit/Source	Fuel Consumption	Fuel Consumption (MMBtu)
Residential/Commercial		
Natural Gas	(hundred cubic feet)	
Floyd Bennett Field	112,248	11,528
Breezy Point District	42,482	4,363
Petroleum	(gallons)	
Floyd Bennett Field	68,873	9,552
Breezy Point District	8,760	1,215
Wildlife Refuge	4,550	631
Transportation		
Motor Gasoline	(gallons)	
Park-owned, Park-leased Vehicles	11,454	1,433
Park Police Vehicles	36,073	4,512
Visitor Vehicles	540,919	67,653
Marine Park-owned Boats	35,090	4,389
Distillate Fuel Oil	(gallons)	
Park-owned, Park-leased Vehicles	1,325	184
Visitor Vehicles	589	82
Marine Park-owned Boats	10,000	1,387

Note: Residential/commercial fuel consumption provided by park units; transportation fuel consumption calculated as described under Methodology.

Table 4.1-7: Sandy Hook Fuel Consumption

Park Unit/Source	Fuel Consumption (gallons)	Fuel Consumption (MMBtu)
Residential/Commercial		
Distillate Fuel Oil	74,753	10,368
Transportation		
Motor Gasoline		
Park-owned, Park-leased	7,000	876
Visitor Vehicles	640,779	80,143
Marine Park-owned Boats	NAV	
Distillate Fuel Oil		
Park-owned, Park-leased	3,000	416
Visitor Vehicles	5,539	768
Marine Park-owned Boats	NAV	

Notes: Residential/commercial fuel consumption provided by park units; transportation fuel consumption calculated as described under Methodology.
NAV = Not available.

Table 4.1-8: Fuel Combustion Conversions and Factors

Fuel Type	Heat Content	Carbon Content Coefficient (million metric tons C/QBtu)	Fraction Oxidized
Natural Gas	**(Btu/ft^3)**		
Natural Gas	1,027	14.47	99.5%
Petroleum	**(MMBtu/barrel)**		
Distillate Fuel Oil	5.825	19.95	99.0%
Motor Gasoline	5.253	19.34	99.0%

Sources: Heat contents from EIA, *Annual Energy Review 2001*, Tables A1 and A4.
Carbon contents from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*.
Fraction oxidized factors from EIA, *Emissions of Greenhouse Gases in the United States 2000.*

We had park-specific data available to estimate CH_4 and N_2O for park-owned boats only at the Jamaica Bay Unit. Therefore, we quantified emissions at the other units and emissions from visitor boats at Gateway using county-level data. We estimated county CO_2 emissions from boats using EPA data on fuel consumption for recreational marine vessels (see Table 4.1-9). Table 4.1-10 presents these estimates by county. As discussed in Section 3.3.2 (CAP Nonroad Vehicles), we were unable to apportion these county-level emissions to each of the Gateway park units.

Table 4.1-9: County Level Fuel Consumption in Recreational Boats in 1999

Park Unit/County/Fuel	Fuel Consumption (gallons)
Richmond County (Staten Island) [a]	
Gasoline	114,760
Diesel	11,239
Kings County (Brooklyn) [b]	
Gasoline	240,491
Diesel	34,347
Queens County [b]	
Gasoline	638,130
Diesel	84,960
Monmouth County [c]	
Gasoline	6,625,124
Diesel	783,877

Source: EPA 2002b.
[a] The Staten Island Unit is located in Richmond County.
[b] The Jamaica Bay Unit is located in Kings and Queens counties.
[c] The Sandy Hook Unit is located in Monmouth County.

Table 4.1-10: County Level Emissions from Recreational Boats in 1999

Park Unit/County/Fuel	CO_2 Emissions (MTCE)
Richmond County (Staten Island) [a]	
Petroleum	306
Gasoline	275
Diesel	31
Kings County (Brooklyn) [b]	
Petroleum	670
Gasoline	576
Diesel	94
Queens County [b]	
Petroleum	1,761
Gasoline	1,528
Diesel	233
Monmouth County [c]	
Petroleum	18,012
Gasoline	15,865
Diesel	2,147

[a] The Staten Island Unit is located in Richmond County.
[b] The Jamaica Bay Unit is located in Kings and Queens counties.
[c] The Sandy Hook Unit is located in Monmouth County.

Data Sources

A variety of sources were consulted in the estimation of CO_2 emissions from stationary combustion for residential and commercial purposes at Gateway. In the residential/commercial end-use sector, the Staten Island Unit provided fuel consumption data for natural gas used in boilers, furnaces, and water heaters (Dexter 2003). The Jamaica Bay Unit provided fuel consumption data for natural gas used in boilers and water heaters, and distillate fuel used in boilers, furnaces, and generators (Collier 2003). The Sandy Hook Unit provided fuel consumption data for distillate fuel (Home Heating Oil No. 2) used for building heating (Hansen and Diodato 2003). Data on fuel consumption for transportation end uses was very difficult to obtain, particularly with respect to visitor vehicles. Data sources consulted in developing emissions estimates are described below.

In the transportation end-use sector, the Staten Island Unit provided the quantity (in gallons) of diesel fuel used, which included park-owned, park-leased, and Headquarters vehicles. However, in terms of motor gasoline, Staten Island was only able to provide data on purchases for one of the sub-units—Miller Field (Dexter 2003). Because we were unable to approximate gasoline fuel purchased for the other sub-units at Staten Island (i.e., Fort Wadsworth and Great Kills Park) using this minimal gasoline information, gallons of motor gasoline consumed for all vehicle types were instead estimated using the vehicle miles traveled (VMT) estimates (See CAP Mobile Source Section 3.3 for an explanation of how VMT was estimated for each vehicle type). Using this approach, VMT for each vehicle type and vehicle class[17] were divided by U.S. miles per gallon (MPG) averages for each corresponding vehicle type and class. We used this same methodology to estimate gallons of diesel fuel consumed by visitor vehicles at

[17] Vehicle classes at Gateway include: light-duty gas vehicles (LDGV), light-duty diesel vehicles (LDDV), light-duty gas truck (LDGT), light-duty diesel truck (LDDT), heavy-duty gas vehicle (HDGV), and heavy-duty diesel vehicle (HDDV).

the Staten Island Unit. Table 4.1-11 provides these MPG values, which are U.S. averages. MPG values for each vehicle class were obtained or derived from FHWA's *Highway Statistics 2001* (FHWA 2002). No marine fuel consumption data were provided by Staten Island to allow for estimation.

Table 4.1-11: U.S. Miles Per Gallon

	LDGV	LDDV	LDGT	LDDT	HDGV [a]	HDDV [a]
MPG	21.90	21.90	17.44	17.44	5.83	5.83

Source: FHWA 2002, Highway Statistics 2001.
Note: These categories include: LDGV: light-duty gas vehicles; LDDV: light-duty diesel vehicles; LDGT: light-duty gas truck; LDDT: light-duty diesel truck; HDGV: heavy-duty gas vehicle; HDDV: heavy-duty diesel vehicle (HDDV).
[a] Derived using weighted average of FHWA Other Single-unit Trucks and Combination Trucks.

The Jamaica Bay Unit provided a value for the total amount spent on vehicle fuel—motor gasoline and diesel fuel combined—in 2002 (Demers 2003). In order to disaggregate this combined quantity of purchased gasoline and diesel fuel used by both park-owned and park-leased vehicles, fuel proportions were estimated. These proportions were obtained by totaling the corresponding gas and diesel totals of the Jamaica Bay VMT and MPG products for each vehicle type and class. The resulting proportions (90 percent gasoline and 10 percent diesel used by park-owned and leased vehicles in 2002) were multiplied by the combined fuel purchased amount and then converted to gallons using New York City gasoline and diesel prices per gallon for 2002 (provided in Table 4.1-12). These fuel prices were obtained from EIA's *Retail Gasoline Historical Prices and Weekly Retail On-Highway Diesel Prices for NYC* (EIA 2003). Fuel consumption for park police and visitor vehicles (missing from fuel data provided) was calculated as the product of the respective Jamaica Bay VMT and MPG values. Jamaica Bay provided gasoline and diesel fuel consumption data for park-owned boats (McCarthy 2003).

Table 4.1-12: Average Fuel Prices in New York City in 2002

Fuel Type	$/gallon
Diesel Fuel	$1.32
Motor Gasoline	$1.41

Source: EIA 2003.

The Sandy Hook Unit provided fuel consumption data for diesel fuel use for park-owned and leased vehicles (Hansen and Diodato 2003). Because fuel consumed by visitor vehicles was not included in the park unit's data, these gallons were also calculated as the product of the corresponding Sandy Hook VMT and MPG values. No marine fuel consumption data were provided by Staten Island to allow for estimation.

Heat contents were obtained from EIA's *Annual Energy Review 2001* (EIA 2002). Carbon content coefficients and fraction oxidized factors were obtained from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003). A listing of the data sources for all park units is provided in Table 4.1-13.

Table 4.1-13: Data Sources for Estimation of Direct CO_2 Emissions from Fossil Fuel Combustion

Source/Park Unit	Data Source
Direct Emissions: Fuel Combustion (including stationary and mobile)	
All Units	
Heat Contents	EIA, 2002. Tables A1 and A4.
Carbon Content Coefficients Fraction Oxidized Factors	EPA, 2003b.
U.S. MPG	FHWA, 2002.
Fuel Prices in New York City	EIA, 2003.
Park Unit VMT	Demers, 2003; Hansen, 2003; Diodato, 2003. For more detail, see CAP Mobile Section 3.3.
County-level recreational marine vessel fuel use data	EPA, 2002b.
Staten Island Unit	
Fuel Consumption Data	Dexter, 2003.
Jamaica Bay Unit	
Fuel Consumption Data for Stationary Sources	Collier, 2003.
Fuel Purchased Data for Vehicles	Taunton, 2003.
Fuel Consumption Data for Marine Boats	McCarthy, 2003.
Sandy Hook Unit	
Fuel Consumption Data	Hansen, 2003; Diodato, 2003.

4.1.2 Indirect Emissions from Purchased Electricity

Results

CO_2, CH_4, and N_2O are emitted to the atmosphere as fossil fuels are combusted to produce electricity. Emissions of these gases actually occur at electric power facilities, which are outside the park's boundaries. However, since Gateway's use of purchased electricity indirectly causes GHG emissions, they are considered "indirect" emissions. The resulting emissions depend on the amount of energy used and the mix of fuel that goes into electricity generation. For example, if hydroelectric or nuclear power provides much of the electricity, GHG emissions from this source would be much lower than if it were primarily generated by fossil fuels.

For this report, we limited our estimates of emissions from purchased electricity to CO_2. The reason for this is twofold. Whereas CO_2 emissions from fuel combustion are primarily dependent on the carbon content of the fuel, emissions of CH_4 and N_2O are much more complex. The characteristics of the fuel, combustion technology, control technology, environmental conditions, and other factors can affect the amount of CH_4 and N_2O emitted. In addition, emissions of these gases only represent 0.5 percent of U.S. emissions from fuel combustion from stationary sources, while CO_2 represents almost all emissions (99.5 percent) (EPA 2003b).

Purchased electricity resulted in an estimated 1,946 MTCE of indirect CO_2 emissions. The Jamaica Bay and Staten Island Units accounted for approximately 47 and 44 percent of these emissions, respectively, while the Sandy Hook Unit accounted for only 10 percent. Lower emissions from Sandy Hook correspond to significantly lower electricity purchases than the other units. Table 4.1-14 presents these emission results by park unit.

Table 4.1-14: Indirect CO_2 Emissions from Purchased Electricity

Source/Park Unit	Emissions (MTCE)
Indirect Emissions: Purchased Electricity	**1,946**
Staten Island Unit	850
Jamaica Bay Unit	908
Sandy Hook Unit	187

Methodology

The methodology employed for estimating emissions from electricity is described in the World Resources Institute and the World Business Council for Sustainable Development's *GHG Protocol Initiative* (2001), as well as EPA's Climate Protection Partnerships Division's *Climate Leaders Greenhouse Gas Inventory Protocol* (2002).

The net generation of electricity was estimated using purchasing data collected from each park unit. On average, about 9 percent of the electricity generated in the U.S. is lost before it reaches the consumer, due to transmission and distribution losses. These losses must be taken into account; therefore, a loss factor of 0.09 was applied to purchased electricity from each park unit to estimate net generation.

$$\textit{Net Generation of Electricity (MWh)} = \textit{Electricity Purchased (kWh)} * 1\ \textit{MWh}/10^3\ \textit{kWh} \div (1-\textit{Loss Factor})$$

EPA's eGRID model was used to determine CO_2 emission rates for each location (EPA 2002). Emission factors for 2000 (the latest year available) were selected for the eGRID subregion in which each park unit was located, since it was assumed that electricity consumed in these subregions represented the most accurate depiction of the electricity purchased by each unit (see Table 4.1-15).[18] These emission factors, obtained in (lbs CO_2/MWh), were converted to (MTCE/MWh) using the formula below:

$$\textit{Emission Factor (MTCE/MWh)} = \textit{eGRID Emission Factor (lb } CO_2\textit{/MWh)} \div 2{,}000\ \textit{lbs/short ton} * 0.90718\ \textit{mt/short ton} * 12\ C/44\ CO_2$$

[18] These subregions are defined by eGRID as the following: "eGRID subregions represent a portion of the U.S. power grid that is contained within a single NERC region. eGRID divides the U.S. power grid into 27 different eGRID subregions, plus an "Off-Grid" category for plants that are not grid-connected. Most of eGRID's subregions consist of one or more power control areas (PCAs), except for the New York ISO, which has been divided into three geographic eGRID subregions. eGRID subregions generally represent sections of the power grid that have similar emissions and resource mix characteristics and may be partially isolated by transmission constraints. eGRID's subregions correspond in most cases to subregions used by the North American Electric Reliability Council (i.e., subregions of NERC regions) and to IPM® regions developed by ICF Consulting." (EPA 2003)

Table 4.1-15: Electricity Emission Factors

Location	Electric Generating Company	eGRID Subregion	Emission Factor (lbs CO_2/MWh) [a]
Staten Island Unit	Con Edison	NPCC NYC/Westchester[b]	1,090.1
Floyd Bennett Field (Jamaica Bay Unit)	Con Edison	NPCC NYC/Westchester[b]	1,090.1
Breezy Point (Jamaica Bay Unit)	Long Island Power Authority	NPCC NYC/Westchester[b]	1,090.1
Sandy Hook Unit	Jersey Central Power & Light	MAAC All[c]	1,097.1

[a] Emission factors selected from the eGRID Subregion
[b] NPCC NYC/Westchester fuel mix consists of oil, gas, nuclear, waste, biomass, and hydro.
[c] MAAC All fuel mix consists of coal, oil, gas, nuclear, waste, biomass, hydro, and wind.

The electricity generated for purchase and use by each park location (as calculated above) was then multiplied by the appropriate CO_2 emission rate to yield emissions in MTCE, as described below.

*CO_2 Emissions (MTCE) = Net Generation of Electricity (MWh) * Emission Factor (MTCE/MWh)*

Data Sources

CO_2 emission rates were obtained for the eGRID Subregions in which the park units are located were obtained from EPA's eGRID model (EPA 2003). These two subregions are *NPCC NYC/Westchester* and MAAC All. The average loss factor for the U.S. in 2001 was obtained from EIA's Annual Energy Review 2001 (EIA 2002). From electricity bills, each park unit provided their total electricity consumption in kWh (see Table 4.1-16). See Table 4.1-17 for more specific information on where these data were obtained.

Table 4.1-16: Purchased Electricity Reported by Each Park Unit

Source/Park Unit	Purchased Electricity (kWh)
Total Purchased Electricity	**13,121,410**
Staten Island Unit	5,738,427
Jamaica Bay Unit	6,126,647
Sandy Hook Unit	1,256,336

Table 4.1-17: Data Sources for Estimation of Indirect CO_2 Emissions from Purchased Electricity

Source/Park Unit	Data Source
Indirect Emissions: Purchased Electricity	
All Units	
Emission Factors (in lb CO_2/MWh)	EPA, 2003a.
Loss Factor	EIA, 2002.
Staten Island Unit	
Purchased Electricity (in kWh)	Saslaw, 2003.
Jamaica Bay Unit	
Purchased Electricity (in kWh)	Collier, 2003.
Sandy Hook Unit	
Purchased Electricity (in kWh)	Connolly, 2003.

4.2 CH_4 AND N_2O FROM STATIONARY COMBUSTION[19]

Fossil fuel combustion in stationary sources results in emissions of CO_2, CH_4, and N_2O. In accordance with GHG inventory guidance, CO_2 emissions from fossil fuel combustion at Gateway were estimated and reported separately (see Section 4.1). Stationary combustion sources owned and operated by Gateway include space and water heating equipment (boilers, furnaces, water heaters), fireplaces, and campfires. GHG emissions from campfires are not typically reported in GHG inventories. However, the availability of data collected for the CAP calculations and an appropriate emission factor enabled the estimation of N_2O emissions from campfires.

Results

Combined emissions of CH_4 and N_2O emissions from stationary sources comprised approximately 0.1 percent of total GHG emissions from Gateway National Recreation Area (see Table 4.2-1). Of the total GHG emissions from stationary sources, the Staten Island, Jamaica Bay, and Sandy Hook units accounted for the following:

- 70, 7, and 23 percent, respectively, of CH_4 emissions; and
- 16, 64, and 20 percent, respectively, of N_2O emissions.

Jamaica Bay's lower CH_4 emissions and higher N_2O emissions compared to other two units can be partially explained by the use of a more detailed method for estimating emissions because of the availability of fuel consumption data for various types of heating equipment for this unit. The method applied to Staten Island and Sandy Hook's data uses an emission factor for CH_4 that is much higher than that for N_2O. Additionally, Staten Island's contribution to the vast majority of CH_4 emissions corresponds with the higher total fuel consumption for space and water heating equipment reported by this unit. A similar trend is not shown in the N_2O emission results because of the greater number of campfires and associated emissions at Sandy Hook.

Table 4.2-2 presents stationary CH_4 and N_2O emissions in MTCE disaggregated for each respective park unit by combustion source (i.e., heating equipment, fireplaces, and campfires).

Table 4.2-1: CH_4 and N_2O Emissions from Stationary Combustion

Park Unit	Emissions (MTCE)		
	CH_4	N_2O	Total
Stationary Combustion	**2.6**	**3.2**	**5.8**
Staten Island Unit	1.8	0.5	**2.3**
Jamaica Bay Unit	0.2	2.2	**2.4**
Sandy Hook Unit	0.6	0.7	**1.3**

[19] CO_2 emissions from fossil fuel combustion in stationary sources are covered in Section 4.1.

Table 4.2-2: CH_4 and N_2O Emissions by Combustion Source

Park Unit/Source	Emissions (MTCE)		
	CH_4	N_2O	Total
Total	**2.6**	**3.2**	**5.8**
Staten Island Unit	**1.8**	**0.5**	**2.3**
Space and Water Heating Equipment	1.8	0.5	2.3
Boilers	*IE*	*IE*	*IE*
Furnaces	*IE*	*IE*	*IE*
Water Heaters	*IE*	*IE*	*IE*
Campfires	NA	+	+
Jamaica Bay Unit	**0.2**	**2.2**	**2.4**
Space and Water Heating Equipment	0.2	2.2	2.3
Boilers	*0.2*	*2.2*	*2.3*
Furnaces	*+*	*+*	*+*
Water Heaters	*NE*	*NE*	*NE*
Campfires	NA	+	+
Sandy Hook Unit	**0.6**	**0.7**	**1.3**
Space and Water Heating Equipment	0.6	0.5	1.1
Boilers	*IE*	*IE*	*IE*
Furnaces	*IE*	*IE*	*IE*
Water Heaters	*IE*	*IE*	*IE*
Fireplaces	NA	+	+
Campfires	NA	0.1	0.1

Note: NA = Not applicable.
NE = Not estimated.
IE = Included elsewhere. We were unable to estimate emissions by combustion source for Staten Island and Sandy Hook. Instead, emissions from fossil fuel combustion by stationary sources at these units are reported collectively under the "space and water heating equipment" subtotals.
+ Does not exceed 0.05 MTCE.

Methodology

Emissions of CH_4 and N_2O from stationary combustion depend on the type of fuel used (e.g., distillate fuel oil, natural gas, wood), the equipment, operating conditions, and maintenance and vintage of the technology. The Intergovernmental Panel on Climate Change (IPCC) outlines two different approaches in *IPCC Guidelines for National Greenhouse Gas Inventories* (1997) for estimating stationary combustion emissions. The recommended IPCC Tier 2 approach employs equipment- and fuel-specific emission factors, nearly all of which are taken from EPA's *Compilation of Air Pollutant Emission Factors 1998* (AP-42).[20] The IPCC Tier 1 approach uses less detailed emission factors for use in situations where equipment and technology information are unavailable. Each park unit provided information on its space and water heating equipment to varying levels of detail. Based on the data available, we applied the Tier 2 methodology using the AP-42[21] emission factors to the greatest extent possible, and the Tier 1 approach and emission factors in all other cases. This approach is analogous to the approach used to estimate CAP emissions from stationary sources (see CAP Stationary Point Source Section 3.1 for a

[20] These emission factors were also provided in the NPS *Air Emission Inventory Preparation Protocol* (2001).
[21] Although they are consistent with IPCC Tier 2 emission factors, we used AP-42 emission factors across the board, because AP-42 provided some emission factors that were not provided by IPCC.

complete description). The sections that follow describe the methodologies used to calculate CH_4 and N_2O emissions for space and water heating equipment and fireplaces.

Space and Water Heating Equipment

Among the park units, only the Jamaica Bay Unit was able to provide detailed space and water heating equipment information enabling emissions to be calculated for boilers and furnaces individually. Based on the fuel consumption data for boilers and furnaces, emissions were estimated using equipment-specific emission factors from EPA's *Compilation of Air Pollutant Emission Factors 1998* (AP-42) and following the IPCC recommended Tier 2 approach. Emissions from water heaters could not be calculated because fuel consumption data were not available.

The Jamaica Bay Unit reported boiler capacities of less than 100 million British thermal units per hour (Btu/hr) used with either distillate oil (specifically, home heating fuel no. 2) or natural gas. Fuel consumption data for boilers were provided in gallons per year for heating fuel no. 2 and hundred cubic feet per year for natural gas. Fuel consumption data were converted to lb/1000 gallons units for heating fuel and to lb/10^6 standard cubic feet (scf) units for natural gas (i.e., from gallons per year to 1000 gallons per year and from hundred cubic feet to million cubic feet). The appropriate emission factors for distillate and natural gas-fired boilers were chosen based on the boiler capacity size, type (residential), and control technology (in this case, none[22]), and taken from EPA's Compilation of Air Pollutant Emission Factors 1998 (See Table 4.2-3). Fuel consumption data (in the appropriate units) were then multiplied by the boiler, fuel, and gas-specific emission factors to calculate these emissions for the Jamaica Bay Unit. This method follows the formula below:

Emissions (lbs) = Fuel Consumption (1000 gal or 10^6 scf) x Emission Factor (lb/1000 gal or lb/10^6 scf)

CH_4 and N_2O emissions from furnaces were also calculated using this approach. Furnaces that used heating fuel no. 2 or natural gas were assumed to be residential. Fuel consumption data (in gallons) were multiplied by the corresponding emission factor for each gas (Table 4.2-3) to estimate CH_4 and N_2O emissions.

Both Sandy Hook and Staten Island provided total fuel consumed in all heating equipment in residential buildings. Because fuel consumption was not available by type of heating equipment, these emissions were estimated using the IPCC Tier 1 methodology.[23]

Table 4.2-3: Tier 2 CH_4 and N_2O Space and Water Heating Emission Factors

[22] All equipment was assumed to be uncontrolled because park personnel either indicated that there were not control technologies in place or did not provide specific control technology information.
[23] Although some information was provided for certain heating units, total consumption was not available at this level of detail.

Source	Type	Emission Factors	
		CH_4	N_2O
Distillate Fuel Oil Fired [a]		**(lb/1000 gal)**	
Boilers (<100 MMBtu/hr)	Commercial/Institutional, Residential	0.216	0.11
Furnaces	Residential	1.78	0.05
Natural Gas Fired		**(lb/10^6 cubic feet)**	
Boilers (<100 MMBtu/hr)	Uncontrolled	2.3	2.2
Furnaces (<0.3 MMBtu/hr)	Residential Uncontrolled	2.3	2.2

[a] Used for heating fuel oil no. 2, a specific product of distillate fuel oil used for space heating.
Source: EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42).

To convert Sandy Hook's distillate fuel oil consumption from gallons to GJ, gallons were first divided by 42 gallons/barrel and multiplied by the heat content for distillate fuel of 5.825 MMBtu/barrel and by 10^6 Btu/MMBtu. To convert Staten Island's natural gas consumption from therms to Btu, therms were multiplied by 100,000 Btu/therm. Distillate and natural gas fuel use in gross calorific values (GCV) were then converted to the net calorific values (NCV) using the heating value conversion of 95 percent for petroleum and 90 percent for natural gas.[24] These quantities in Btu were then multiplied by 1.055×10^{-6} GJ/Btu to obtain fuel consumption in GJ. These data conversions from physical units to GJ are shown in the equations below:

Distillate Energy Content (GJ) = *Fuel Consumption (gal) ÷ (42 gal/barrel x 5.825 MMBtu Distillate Oil/barrel x 10^6 Btu/MMBtu) x 95% GCV to NCV x (1.055×10^{-6} GJ/Btu)*

Natural Gas Energy Content (GJ) = *Fuel Consumption (therms) x (100,000 Btu/therm) x 90% GCV to NCV x (1.055×10^{-6} GJ/Btu)*

The Tier 1 approach uses aggregated emission factors that are based on primary fuel type (coal, petroleum, natural gas) and end-use, in this case residential. These emission factors are taken from the IPCC Guidelines (1997) and are provided in provided in grams of gas/GJ (See Table 4.2-4). Emissions of each gas were then calculated by multiplying fuel energy content (in GJ) by the appropriate Tier 1 emission factor and converting to metric tons (mt). The equation is described below:

Emissions (mt) = *(Fuel Consumption (GJ) x Emission Factor (g/GJ)) ÷ 453.6 g/lb ÷ 2000 lbs/short ton x 0.9072 mt/short ton*

Table 4.2-4: Tier 1 Stationary GHG Emission Factors

[24] Fuel use in the United States is typically measured in gross calorific values (GCV). Since the emission factors used are based on fuel reported in net calorific values (NCV), energy content in GCV was converted to NCV using these simplified conversions from the International Energy Agency.

Source	Type	Emission Factors (g gas/GJ)	
		CH_4	N_2O
Distillate Fuel Oil Fired	Residential	10.0	0.6
Natural Gas Fired	Residential	5.0	0.1

Source: IPCC/UNEP/OECD/IEA, 1997.

To obtain emissions for each park unit in MTCE, the emissions of CH_4 and N_2O (in metric tons) were multiplied by the GWP for each gas (21 for CH_4; 310 for N_2O) and the mass ratio of carbon to CO_2 (12/44).

Fireplaces

The Sandy Hook Unit was the only Gateway park unit to provide information on fireplaces. The Sandy Hook Unit provided data on wood consumed in units of cords per year. Emissions were estimated by converting fuel consumption from cords to tons and multiplying by the appropriate emission factors (Table 4.2-5). Only N_2O emissions from fireplaces were estimated, as neither IPCC nor AP-42 provide an emission factor for CH_4. N_2O emissions were estimated using the appropriate emission factor from AP-42 as shown in the following equation:

Emissions (mt) = Fuel Consumption (cords) x 1.12 short tons/cord x Emission Factor (lb/short ton) ÷ 2000 lbs/short ton x 0.9072 mt/short ton

To convert emissions to MTCE, emissions of N_2O (in metric tons) were multiplied by the N_2O GWP of 310 and the mass ratio of carbon to CO_2 (12/44).

Table 4.2-5: Tier 2 CH_4 and N_2O Fireplace Emission Factors

Source	Emission Factors (lb/short ton)	
	CH_4	N_2O
Fireplaces		
Wood	NAV	0.3

Source: EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42).
Note: NAV = Not available.

Campfires

Public use of campfires is available primarily at the Jamaica Bay Unit, where there are 4 campsite locations. The Sandy Hook Unit only allows campfires for Boy Scouts during the summer, and the Staten Island Unit only allows campfires on special occasions. To estimate emissions from campfires, wood consumption (lbs) for campfires was estimated by multiplying the number of camps by the average pounds of wood used per campfire, which the Sandy Hook Unit assumed to be 10 lbs. Emissions were then calculated by converting wood consumption into short tons and multiplying by the corresponding AP-42 emission factors (in Table 4.2-6). Only N_2O emissions from campfires were estimated, as neither IPCC nor AP-42 provide an emission factor for CH_4. We estimated N_2O emissions as shown in the following equations:

Fuel Consumption (tons) = (Number of Camps x 10 avg. lb wood/campfire) ÷ 2000 lbs/short ton

Emissions (mt) = *Fuel Consumption (tons) x Emission Factor (lb/ton) ÷ 2000 lbs/short ton x 0.9072 mt/short ton*

To convert emissions to MTCE, the emissions of N_2O (in metric tons) were multiplied by the N_2O GWP of 310 and the mass ratio of carbon to CO_2 (12/44).

Table 4.2-6: Tier 2 CH_4 and N_2O Campfire Emission Factors

Source	Emission Factors (lb/short ton)	
	CH_4	N_2O
Campfires		
Wood	NAV	0.3

Source: EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42).

Notes: NAV = Not available. The emission factors for campfires are the same as those for fireplaces.

Data Sources

Table 4.2-7 presents the sources of activity data and emission factors used in the CH_4 and N_2O emission calculations for stationary combustion.

Table 4.2-7: Data Sources for CH_4 and N_2O Emission Estimates of Stationary Combustion

Park Unit/Source	Data Source
All Units	
N_2O Emission Factor for Fireplaces and Campfires	EPA, 1998.
Staten Island Unit	
Fuel Consumption Data for heating equipment and Campsite Data	Dexter, 2003.
CH_4 and N_2O Emission Factors for all Residential Natural Gas Space and Water Heating Equipment	IPCC/UNEP/OECD/IEA, 1997.
Jamaica Bay Unit	
Fuel Consumption Data for heating equipment	Collier, 2003.
Campsite Data	Wolff, 2003.
N_2O Emission Factors for Distillate Fuel Boilers and Furnaces	EPA, 1998.
CH_4 Emission Factors for Natural Gas Boilers and Furnaces	EPA, 1998.
Sandy Hook Unit	
Fuel Consumption Data for heating equipment, Fireplace, and Campsite Data	Hansen and Diodato, 2003.
CH_4 and N_2O Emission Factors for all Residential Distillate Fuel Space and Water Heating Equipment	IPCC/UNEP/OECD/IEA, 1997.

4.3 CH_4 AND N_2O FROM MOBILE COMBUSTION

In accordance with national and state GHG inventory guidance, CO_2 emissions from fossil fuel combustion in mobile sources are reported separately from other GHG emissions from these sources (see Section 4.1). This section provides estimates of N_2O and CH_4 emissions from mobile combustion. These emissions (totaling approximately 132 MTCE) comprised roughly 2 percent of total GHG emissions from Gateway National Recreation Area. Emissions from highway vehicles accounted for nearly all of these emissions (131 MTCE), while non-highway vehicles (e.g., boats) accounted for the remainder. Of the total highway and non-highway GHGs emitted from this source, the Staten Island, Jamaica Bay, and Sandy Hook units accounted for 23, 39, and 38 percent, respectively. Emissions from Headquarters and Park Police vehicles are included within the Staten Island and Jamaica Bay totals, respectively. Table 4.3-1 provides highway and non-highway emissions by park unit, as well as for Park Police and Headquarters. The sections that follow describe the results, methodology, and data sources for estimating CH_4 and N_2O emissions from combustion in highway and non-highway vehicles.

Table 4.3-1: Gateway Summary of N_2O and CH_4 Emissions from Mobile Sources

Source/Park Unit	Emissions (MTCE)		
	CH_4	N_2O	Total
Highway Vehicles	**5.6**	**125.0**	**130.7**
Staten Island Unit	1.4	28.6	30.1
Jamaica Bay Unit	1.8	48.6	50.3
Sandy Hook Unit	2.4	47.8	50.3
Nonroad Vehicles	**0.2**	**1.1**	**1.3**
Staten Island Unit	0.0	0.1	0.2
Jamaica Bay Unit	0.2	1.0	1.1
Sandy Hook Unit	NE	NE	NE
Total	**5.8**	**126.1**	**132.0**

Note: Totals may not sum due to independent rounding.
NE = Not estimated.

4.3.1 Highway Vehicles

Results

N_2O and CH_4 emissions from highway vehicles result from chemical processes that occur during combustion of fuel and catalytic after-treatment of exhaust gases. A total of 131 MTCE from highway sources were emitted from Gateway. Of this total, the Staten Island Unit accounted for 23 percent, the Jamaica Bay unit accounted for 36 percent, and the Sandy Hook Unit accounted for 38 percent while Park Police and Headquarters vehicles accounted for 2 and 0.1 percent, respectively.[25]

Table 4.3-2 summarizes each park unit's emissions, disaggregated into park-owned, park-leased, and visitor vehicles, with Headquarters and Park Police vehicles included under Staten Island and Jamaica Bay, respectively. As the table shows, visitor vehicles comprised the vast majority of N_2O and CH_4 emissions from mobile sources, accounting for 98 percent of the Staten Island Unit's emissions, 91

[25] Note that for the purposes of aggregating inventory results by park unit, Headquarters vehicles are included in Staten Island

percent of emissions from the Jamaica Bay Unit, and 97 percent of the Sandy Hook Unit's emissions. Variation among the park unit emissions is almost entirely attributable to differences in vehicle miles traveled (VMT) across these units. However, this variation was also affected by differences in the vehicle fleet age distribution between the Jamaica Bay Unit and the other units.

Table 4.3-2: Gateway Summary of Highway N_2O and CH_4 Emissions

Source/Park Unit	Emissions (MTCE)		
	CH_4	N_2O	Total
Highway Vehicles	**5.6**	**125.0**	**130.7**
Staten Island Unit	**1.4**	**28.6**	**30.1**
Park-Owned Vehicles	+	0.1	0.1
Park-Leased Vehicles	+	0.3	0.3
Visitor Vehicles	1.4	28.1	29.5
Headquarters	+	0.1	0.1
Jamaica Bay Unit	**1.8**	**48.6**	**50.3**
Park-Owned Vehicles	+	0.1	0.1
Park-Leased Vehicles	0.1	1.0	1.1
Visitor Vehicles	1.5	44.5	46.0
Park Police	0.2	3.0	3.2
Sandy Hook Unit	**2.4**	**47.8**	**50.3**
Park-Owned Vehicles	0.1	0.8	0.9
Park-Leased Vehicles	+	0.7	0.8
Visitor Vehicles	2.3	46.3	48.7

Note: Totals may not sum due to independent rounding.
+ Does not exceed 0.05 MTCE.

Methodology

Estimates of N_2O and CH_4 from highway vehicles are based on vehicle miles traveled (VMT) and are specific to individual vehicle type and control technology. For example, a light-duty gasoline vehicle with a three-way catalyst will have a different emissions profile than a heavy-duty gasoline vehicle with an oxidation catalyst. Thus, in order to estimate emissions, it is necessary to obtain VMT broken down by vehicle type and by control technology.

In order to estimate N_2O and CH_4 emissions from highway vehicles at Gateway National Recreation Area, the following data were requested from each park unit:

- VMT by vehicle type;
- control technology distribution by vehicle type, for all model years;
- age distribution by vehicle type; and
- annual vehicle mileage accumulation by vehicle type, for all model years.

The park units provided VMT data for park owned and leased vehicle fleets.[26] Visitor VMT was estimated using data on miles of roads and number of vehicles entering the park annually. The

totals, while Park Police vehicles are included in Jamaica Bay totals.
[26] These estimates were subsequently converted to vehicle types [i.e., light-duty gas vehicles (LDGV), light-duty diesel vehicles (LDDV), light-duty gas truck (LDGT), light-duty diesel truck (LDDT), heavy-duty gas vehicle (HDGV), heavy-duty diesel vehicle (HDDV), and motorcycles] based on ratios provided in EPA's Mobile 6.2 model.

calculations assumed that vehicles traveled the entire distance of road miles on a one-way trip within the park unit, and that two one-way trips equaled a roundtrip. Table 4.3-3 presents the VMT estimates for each of the park units. The calculation of VMT for each vehicle category and park unit is described in further detail in the Section 3.3.1 (CAP Highway Vehicle Emissions).

Since federal and state control technology standards have changed over the past thirty years, N_2O and CH_4 emissions depend on the control technology distribution for each vehicle type in the fleet, for each model year. In order to develop this distribution, it was necessary to take into account both the age distribution of the fleet, and the relative distance these vehicles drive in the park annually. By cross-multiplying these two sets of data, VMT by vehicle age was obtained for each vehicle type. National default vehicle age data from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003) were used to develop this distribution for all units except Jamaica Bay, which provided its own vehicle age distribution. Jamaica Bay park personnel indicated that this unit-specific age distribution should not be used for the other two park units (Demers 2003). The CE-CERT vehicle age fractions developed for the NPS (CE-CERT 2000) and used in the CAP estimation do not contain the fuel type categories needed for GHG estimation. Thus, the national vehicle age defaults were used for the Staten Island and Sandy Hook GHG calculations. Table 4.3-4 and Table 4.3-5 show the VMT distribution by vehicle age for the Jamaica Bay Unit and all other units, respectively. National defaults were used for control technology distribution, age distribution, and annual vehicle mileage accumulation (EPA 2003).

Starting with VMT, the following steps were taken to estimate emissions of CH_4 and N_2O from highway vehicles: (1) allocate VMT (for each vehicle type) by control technology and vehicle age; (2) sum VMT estimates across vehicle age to obtain VMT by vehicle type and control technology; (3) use emission factors to convert VMT to emissions for each vehicle/control technology combination; and (4) calculate total emissions in MTCE.

Table 4.3-3: VMT by Park Unit

Vehicle Type	Staten Island[27]	Jamaica Bay	Sandy Hook
Total VMT	**8,624,887**	**12,070,527**	**14,381,398**
Park-Owned Vehicles	**22,710**	**13,460**	**110,926**
Light-Duty Gasoline Vehicles (LDGV)	NA	4,464	4,609
Light-Duty Gasoline Trucks (LDGT)	10,755	5,439	33,537
Heavy-Duty Gasoline Vehicles (HDGV)	3,388	2,644	53,766
Light-Duty Diesel Vehicles (LDDV)	NA	4	NA
Light-Duty Diesel Trucks (LDDT)	1,792	NA	5,589
Heavy-Duty Diesel Vehicles (HDDV)	6,775	909	13,425
Motorcycles	NA	NA	NA
Park-Leased Vehicles	**49,823**	**198,568**	**197,712**
Light-Duty Gasoline Vehicles (LDGV)	NA	79,991	115,972
Light-Duty Gasoline Trucks (LDGT)	37,367	104,310	68,256
Heavy-Duty Gasoline Vehicles (HDGV)	12,456	7,637	NA
Light-Duty Diesel Vehicles (LDDV)	NA	NA	104
Light-Duty Diesel Trucks (LDDT)	NA	NA	13,380
Heavy-Duty Diesel Vehicles (HDDV)	NA	6,630	NA
Motorcycles	NA	NA	NA
Visitor Vehicles	**8,552,355**	**11,858,499**	**14,072,760**
Light-Duty Gasoline Vehicles (LDGV)	8,543,456	11,847,207	14,029,990
Light-Duty Gasoline Trucks (LDGT)	NA	NA	NA
Heavy-Duty Gasoline Vehicles (HDGV)	47	24	1,187
Light-Duty Diesel Vehicles (LDDV)	7,696	10,672	12,638
Light-Duty Diesel Trucks (LDDT)	NA	NA	NA
Heavy-Duty Diesel Vehicles (HDDV)	1,156	596	28,945
Motorcycles	NA	NA	NA
Headquarters Vehicles	**24,911**	NA	NA
Light-Duty Gasoline Vehicles (LDGV)	6,228	NA	NA
Light-Duty Gasoline Trucks (LDGT)	18,683	NA	NA
Heavy-Duty Gasoline Vehicles (HDGV)	NA	NA	NA
Light-Duty Diesel Vehicles (LDDV)	NA	NA	NA
Light-Duty Diesel Trucks (LDDT)	NA	NA	NA
Heavy-Duty Diesel Vehicles (HDDV)	NA	NA	NA
Motorcycles	NA	NA	NA
Park Police Vehicles	NA	**740,568**	NA
Light-Duty Gasoline Vehicles (LDGV)	NA	547,236	NA
Light-Duty Gasoline Trucks (LDGT)	NA	193,332	NA
Heavy-Duty Gasoline Vehicles (HDGV)	NA	NA	NA
Light-Duty Diesel Vehicles (LDDV)	NA	NA	NA
Light-Duty Diesel Trucks (LDDT)	NA	NA	NA
Heavy-Duty Diesel Vehicles (HDDV)	NA	NA	NA
Motorcycles	NA	NA	NA

Note: NA = Not applicable.

[27] Staten Island gasoline vehicle totals include dual fuel compressed natural gas (CNG) vehicles because adequate data were not available on the proportion of time that CNG was used versus gasoline.

Table 4.3-4: VMT Distribution by Vehicle Age for the Jamaica Bay Unit

Vehicle Model Year	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
2002	10.6%	4.8%	0.0%	7.5%	0.0%	0.0%	19.4%
2001	20.2%	0.0%	0.0%	9.5%	0.0%	0.0%	21.2%
2000	0.0%	12.6%	0.0%	9.0%	0.0%	0.0%	15.8%
1999	0.0%	3.9%	0.0%	8.6%	0.0%	0.0%	11.8%
1998	8.7%	11.1%	0.0%	8.1%	0.0%	0.0%	8.8%
1997	0.0%	10.4%	0.0%	7.7%	0.0%	0.0%	6.4%
1996	0.0%	0.0%	0.0%	7.2%	0.0%	0.0%	4.6%
1995	7.5%	3.0%	6.8%	6.7%	0.0%	0.0%	3.3%
1994	14.2%	5.6%	0.0%	6.2%	0.0%	0.0%	2.3%
1993	0.0%	2.6%	11.9%	5.6%	0.0%	0.0%	1.6%
1992	12.8%	0.0%	0.0%	5.0%	0.0%	0.0%	1.1%
1991	6.1%	0.0%	0.0%	4.4%	0.0%	25.7%	3.7%
1990	5.8%	0.0%	0.0%	3.5%	0.0%	23.5%	0.0%
1989	0.0%	24.7%	55.0%	2.7%	0.0%	0.0%	0.0%
1988	5.2%	8.7%	0.0%	2.0%	0.0%	0.0%	0.0%
1987	0.0%	1.6%	0.0%	1.5%	0.0%	0.0%	0.0%
1986	4.7%	0.0%	3.8%	1.1%	47.8%	0.0%	0.0%
1985	0.0%	4.0%	0.0%	0.9%	0.0%	0.0%	0.0%
1984	4.3%	1.2%	6.6%	0.6%	40.2%	0.0%	0.0%
1983	0.0%	1.1%	6.2%	0.5%	0.0%	0.0%	0.0%
1982	0.0%	4.0%	0.0%	0.4%	0.0%	0.0%	0.0%
1981	0.0%	0.0%	0.0%	0.3%	0.0%	10.5%	0.0%
1980	0.0%	0.0%	5.1%	0.2%	0.0%	0.0%	0.0%
1979	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%
1978	0.0%	0.7%	0.0%	0.4%	12.0%	32.3%	0.0%
1977	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1976	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1975	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.0%
1974	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1973	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1972	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.0%
1971	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1970	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1969	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1968	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1967	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1966	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1965	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1964	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1963	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1962	0.0%	0.0%	0.0%	0.0%	0.0%	8.1%	0.0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Clardy 2003; Demers 2003.
Note: These categories include: LDGV: Light-Duty Gas Vehicles; LDGT: Light-Duty Gas Trucks; HDGV: Heavy-Duty Gas Vehicles; LDDV: Light-Duty Diesel Vehicles; LDDT: Light-Duty Diesel Trucks; HDDV: Heavy-Duty Diesel Vehicles; and MC: Motorcycles.

Table 4.3-5: VMT Distribution by Vehicle Age Used for Staten Island and Sandy Hook Units

Vehicle Model Year	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
2001	7.5%	9.4%	7.9%	7.5%	11.5%	8.3%	19.4%
2000	9.5%	11.6%	13.5%	9.5%	13.1%	14.0%	21.2%
1999	9.0%	10.6%	11.1%	9.0%	11.1%	11.9%	15.8%
1998	8.6%	9.7%	9.9%	8.6%	9.5%	10.1%	11.8%
1997	8.1%	8.8%	8.4%	8.1%	8.1%	8.5%	8.8%
1996	7.7%	7.9%	7.2%	7.7%	6.9%	7.2%	6.4%
1995	7.2%	7.0%	6.2%	7.2%	5.9%	6.1%	4.6%
1994	6.7%	6.2%	5.3%	6.7%	5.0%	5.2%	3.3%
1993	6.2%	5.4%	4.5%	6.2%	4.3%	4.4%	2.3%
1992	5.6%	4.6%	3.9%	5.6%	3.7%	3.7%	1.6%
1991	5.0%	3.8%	3.3%	5.0%	3.1%	3.2%	1.1%
1990	4.4%	3.1%	2.8%	4.4%	2.7%	2.7%	3.7%
1989	3.5%	2.5%	2.4%	3.5%	2.3%	2.3%	0.0%
1988	2.7%	2.0%	2.1%	2.7%	1.9%	1.9%	0.0%
1987	2.0%	1.5%	1.8%	2.0%	1.7%	1.7%	0.0%
1986	1.5%	1.2%	1.5%	1.5%	1.4%	1.4%	0.0%
1985	1.1%	0.9%	1.3%	1.1%	1.2%	1.2%	0.0%
1984	0.9%	0.6%	1.1%	0.9%	1.0%	1.0%	0.0%
1983	0.6%	0.5%	1.0%	0.6%	0.9%	0.9%	0.0%
1982	0.5%	0.4%	0.8%	0.5%	0.8%	0.7%	0.0%
1981	0.4%	0.4%	0.7%	0.4%	0.6%	0.6%	0.0%
1980	0.3%	0.3%	0.6%	0.3%	0.6%	0.5%	0.0%
1979	0.2%	0.3%	0.5%	0.2%	0.5%	0.5%	0.0%
1978	0.2%	0.2%	0.4%	0.2%	0.4%	0.4%	0.0%
1977	0.4%	1.0%	1.8%	0.4%	1.7%	1.7%	0.0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: EPA 2003.
Note: These categories include: LDGV: Light-Duty Gas Vehicles; LDGT: Light-Duty Gas Trucks; HDGV: Heavy-Duty Gas Vehicles; LDDV: Light-Duty Diesel Vehicles; LDDT: Light-Duty Diesel Trucks; HDDV: Heavy-Duty Diesel Vehicles; and MC: Motorcycles.

After obtaining VMT by vehicle age for each vehicle class, these estimates were then further disaggregated by control technology.[28] Because none of the units were able to provide customized control technology distribution data, the national average distribution from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003) was used. After distributing VMT for each vehicle type by vehicle age and control technology, VMT was summed across the vehicle age distribution, resulting in VMT by vehicle type and control technology. Table 4.3-6 provides an example of this distribution, shown for park-owned vehicles at the Staten Island Unit.

Finally, these VMT estimates were converted to emissions by multiplying by the emission factors shown in Table 4.3-7. The resulting emissions estimates were then converted to MTCE by multiplying by the GWP of N_2O (310) and CH_4 (21).

[28] Since N_2O and CH_4 emission factors are specific to individual control technologies, this disaggregation was necessary in order to convert VMT estimates into emissions estimates.

Table 4.3-6: Example of VMT by Control Technology – Staten Island Unit, Park-Owned Vehicles

Control Technology	Vehicle Type						
	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
Three-way Catalyst (T1)	NA	4,970	1,431	NA	NA	NA	NA
Early 3-way Catalyst (T0)	NA	3,031	290	NA	NA	NA	NA
Oxidation Catalyst	NA	565	410	NA	NA	NA	NA
Non-Catalyst	NA	47	620	NA	NA	NA	NA
Low Emission Vehicle	NA	2,140	404	NA	NA	NA	NA
Advanced	NA	NA	NA	NA	1,080	4,060	NA
Moderate	NA	NA	NA	NA	630	2,419	NA
Uncontrolled	NA	NA	233	NA	82	296	NA
Total	NA	**10,755**	**3,388**	NA	**1,792**	**6,775**	NA

Note: NA = Not applicable because the vehicle with the corresponding control technology does not exist in the park-owned vehicle fleet.
These categories include: LDGV: Light-Duty Gas Vehicles; LDGT: Light-Duty Gas Trucks; HDGV: Heavy-Duty Gas Vehicles; LDDV: Light-Duty Diesel Vehicles; LDDT: Light-Duty Diesel Trucks; HDDV: Heavy-Duty Diesel Vehicles; and MC: Motorcycles.

Table 4.3-7: N_2O and CH_4 Emission Factors

Control Technology	Code	Emission Factors by Vehicle Type						
		LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
		N_2O (g/km traveled)						
Three-way Catalyst (T1)	T1	0.0288	0.0361	0.0866				
Early 3-way Catalyst (T0)	T0	0.0507	0.0635	0.1467				
Oxidation Catalyst	O	0.0322	0.0403	0.0932				
Non-Catalyst	N	0.0103	0.0129	0.0298				0.0045
Low Emission Vehicle	L	0.0176	0.0220	0.0704				
Advanced	A				0.0100	0.0200	0.0300	
Moderate	M				0.0100	0.0200	0.0300	
Uncontrolled	U	0.0103	0.0129	0.0298	0.0100	0.0200	0.0300	0.0045
		CH_4 (g/km traveled)						
Three-way Catalyst (T1)	T1	0.0300	0.0350	0.0600				
Early 3-way Catalyst (T0)	T0	0.0400	0.0700	0.0750				
Oxidation Catalyst	O	0.0700	0.0900	0.0900				
Non-Catalyst	N	0.1200	0.1400	0.1250				0.1300
Low Emission Vehicle	L	0.0250	0.0300	0.0440				
Advanced	A				0.0100	0.0100	0.0400	
Moderate	M				0.0100	0.0100	0.0500	
Uncontrolled	U	0.1350	0.1350	0.2700	0.0100	0.0100	0.0600	0.2600

Source: EPA 2003
Note: These categories include: LDGV: Light-Duty Gas Vehicles; LDGT: Light-Duty Gas Trucks; HDGV: Heavy-Duty Gas Vehicles; LDDV: Light-Duty Diesel Vehicles; LDDT: Light-Duty Diesel Trucks; HDDV: Heavy-Duty Diesel Vehicles; and MC: Motorcycles.

Data Sources

VMT data for the park fleet vehicles were provided for all units. VMT for visitor vehicles was calculated by multiplying the number of vehicles entering the park (provided by each of the units) by the number of road miles within each unit. The calculations assume that each vehicle travels the entire length of the park roadway in a one-way trip and then travels the entire length again on the return trip. With the exception of the Jamaica Bay Unit, which provided a customized vehicle age distribution (Demers 2003), the U.S. average age distribution was obtained from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003). The same source was used for average annual vehicle mileage accumulation, control technology distribution, and emission factors for all units.

Table 4.3-8 presents the sources of activity data and emission factors used in the CH_4 and N_2O emission calculations for mobile highway sources in this inventory.

Table 4.3-8: Data Sources for Estimation of CH_4 and N_2O Emissions from Mobile Highway Sources

Park Unit/Source	Data Source
All Units	
Control Technology Distribution; Annual Vehicle Mileage Accumulation; Greenhouse Gas Emission Factors	EPA, 2003.
VMT for park-owned vehicles	Clardy, 2003; Demers, 2003.
Visitor vehicle numbers	Lancos, 2003.
Staten Island Unit	
Park vehicle numbers	Dexter, 2003.
Vehicle Age Distribution	EPA, 2003.
Miller Field road miles	Robinson, 2003.
Jamaica Bay Unit	
Vehicle Age Distribution	Demers, 2003.
Park Police vehicle data	Piccolo, 2003.
Sandy Hook Unit	
Vehicle Age Distribution	EPA, 2003.
Park-leased vehicle data	Barthell, 2003.

4.3.2 Nonroad Vehicles

Results

N_2O and CH_4 emissions from nonroad vehicles result from the combustion of fossil fuels to power nonroad vehicles and equipment and marine vessels and boats. A total of 1.3 MTCE from non-highway sources were emitted from Gateway. Jamaica Bay was responsible for the majority of emissions from this source (1.2 MTCE), with the Staten Island Unit accounting for the remainder. Marine boats located at the Jamaica Bay Unit emitted 1.05 MTCE, or 80 percent of non-highway emissions. The remaining emissions were associated with nonroad vehicles (e.g., tractors, mowers). Due to lack of available data, we were unable to estimate nonroad emissions occurring at the Sandy Hook Unit. Table 4.3-9 summarizes each park unit's nonroad emissions.

Table 4.3-9: Gateway Summary of Nonroad N_2O and CH_4 Emissions

Source/Park Unit	Emissions (MTCE)		
	CH_4	N_2O	Total
Nonroad Park-Owned Vehicles	**0.2**	**1.1**	**1.3**
Staten Island Unit	+	0.1	0.2
Jamaica Bay Unit	0.2	1.0	1.1
Sandy Hook Unit	NE	NE	NE

Note: NE = Not estimated.
+ Does not exceed 0.05 MTCE.

Methodology

Estimates of N_2O and CH_4 from non-highway vehicles were based on fuel consumed by the specific type of non-highway source, and the type of fuel (i.e., diesel fuel, gasoline). Emissions from each type of nonroad vehicle, other equipment, and marine vessels were calculated separately using fuel consumption data provided for each of these categories. In order to estimate emissions, fuel consumption estimates (in gallons) were first converted to kilograms by multiplying by fuel density (in kilograms/gallon). The resulting fuel consumption estimates were then multiplied by emission factors (in grams of emissions per kilogram of fuel) to estimate emissions in units of native gas. These estimates were then converted to MTCE by multiplying by the GWP of N_2O (310) and CH_4 (21).

Table 4.3-10 shows the fuel consumption estimates, and Table 4.3-11 shows the emission factors used to estimate N_2O and CH_4 from non-highway vehicles.

Table 4.3-10: Nonroad Fuel Consumption Estimates

Park Unit/Source/Fuel	Fuel Consumption (gallons)
Staten Island Unit	
Nonroad Vehicles and Other Equipment	
Gasoline	NAV
Diesel	7,500
Marine Boats and Vessels	
Gasoline	NAV
Diesel	NAV
Jamaica Bay Unit	
Nonroad Vehicles and Other Equipment	
Gasoline	NAV
Diesel	4,310
Marine Boats and Vessels	
Gasoline	35,090
Diesel	10,000
Sandy Hook Unit	
Nonroad Vehicles and Other Equipment	
Gasoline	NAV
Diesel	NAV
Marine Boats and Vessels	
Gasoline	NAV
Diesel	NAV

Notes: NAV = Not available. Fuel consumption refers to park-owned vehicles only.

Table 4.3-11: Nonroad N_2O and CH_4 Emission Factors

	CH_4 Emission Factor (g/kg of fuel)		N_2O Emission Factor (g/kg of fuel)	
	Diesel Fuel	Gasoline	Diesel Fuel	Gasoline
Nonroad Vehicles and Other Equipment	0.18	0.18	0.08	0.08
Marine Boats and Vessels	0.23	0.23	0.08	0.08

Because we were only able to estimate CH_4 and N_2O for park-owned marine boats and vessels at Jamaica Bay, we tried to quantify emissions for the other units and for visitor boats at Gateway by using county-level data. Using EPA data on fuel consumption for recreational marine vessels (see Table 4.3-12), we estimated CH_4 and N_2O emissions from boats in each county. Table 4.3-13 presents these estimates. As discussed in Section 3.3.2 (CAP Nonroad Vehicles) and Section 4.1.1 (CO_2 from Fossil Fuel Combustion), we were unable to apportion these county-level emissions to the Gateway park units.

Table 4.3-12: County Level Fuel Consumption in Recreational Boats in 1999

Park Unit/County/Fuel	Fuel Consumption (gallons)
Richmond County (Staten Island) [a]	
Gasoline	114,760
Diesel	11,239
Kings County (Brooklyn) [b]	
Gasoline	240,491
Diesel	34,347
Queens County [b]	
Gasoline	638,130
Diesel	84,960
Monmouth County [c]	
Gasoline	6,625,124
Diesel	783,877

Source: EPA 2002.
[a] The Staten Island Unit is located in Richmond County.
[b] The Jamaica Bay Unit is located in Kings and Queens counties.
[c] The Sandy Hook Unit is located in Monmouth County.

Table 4.3-13: County Level Emissions from Recreational Boats in 1999

Park Unit/County/Fuel	Emissions (MTCE)		
	CH_4	N_2O	Total
Richmond County (Staten Island) [a]			
Petroleum	**0.5**	**2.4**	**2.9**
Gasoline	0.4	2.2	2.6
Diesel	0.0	0.2	0.3
Kings County (Brooklyn) [b]			
Petroleum	**1.0**	**5.3**	**6.3**
Gasoline	0.9	4.6	5.4
Diesel	0.1	0.7	0.9
Queens County [b]			
Petroleum	**2.7**	**13.9**	**16.6**
Gasoline	2.4	12.1	14.4
Diesel	0.4	1.8	2.2
Monmouth County [c]			
Petroleum	**27.7**	**142.4**	**170.2**
Gasoline	24.4	125.5	150.0
Diesel	3.3	16.9	20.2

[a] The Staten Island Unit is located in Richmond County.
[b] The Jamaica Bay Unit is located in Kings and Queens counties.
[c] The Sandy Hook Unit is located in Monmouth County.

Data Sources

Fuel consumption data were provided for the Staten Island Unit (Dexter 2003), and the Jamaica Bay Unit (Collier 2003). The Sandy Hook Unit provided information on nonroad equipment and boat types in the park and their characteristics, but they were unable to report corresponding fuel consumption data. The emission factors used in the nonroad calculations were obtained from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003). Table 4.3-14 presents the sources of activity data and emission factors used in the CH_4 and N_2O emission calculations for nonroad sources in this inventory.

Table 4.3-14: Data Sources for Estimation of CH_4 and N_2O Emissions from Mobile Nonroad Sources

Source/Park Unit	Data Source
All Units	
Emissions Factors	EPA, 2003.
County-level recreational marine vessel fuel use data	EPA, 2002.
Staten Island Unit	
Fuel Consumption Data	Dexter, 2003.
Jamaica Bay Unit	
Nonroad Fuel Consumption Data	Collier, 2003.
Marine Fuel Consumption Data	McCarthy, 2003.

4.4 REFRIGERATION & AIR CONDITIONING

Hydrofluorocarbons (HFCs) are used in refrigeration and air conditioning equipment as a substitute for ozone-depleting substances (ODSs). Production and use of ODSs, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), are controlled internationally under the Montreal Protocol and in the United States by the Clean Air Act. Emissions of these substitutes for ODSs occur during leakage, servicing, and at equipment disposal. At Gateway there were no emissions from stationary refrigeration and air conditioning; all of the emissions from this source resulted from motor vehicle air conditioning. Emissions of HFCs from the substitution of ODSs in refrigeration and air-conditioning end-uses comprised roughly 4 percent of total GHG emissions from Gateway National Recreation Area. Of the 292 MTCE emitted from this source within the park boundaries, the Staten Island Unit, Jamaica Bay Unit, and Sandy Hook Unit accounted for 38, 42, and 20 percent, respectively. Emissions were driven by the number of vehicles and their age distribution at each unit. Because Sandy Hook had both fewer and newer cars, HFC emissions were lower than in the other two units. Additionally, a large number of Park Police vehicles are included in Jamaica Bay's emissions totals, which increased emissions totals. These emissions are summarized in Table 4.4-1.

Table 4.4-1: Gateway Summary of HFC Emissions from Refrigeration and Air Conditioning

Source/Park Unit	Emissions (MTCE)
Stationary Refrigeration and Air Conditioning	**NA**
Staten Island Unit	NA
Jamaica Bay Unit	NA
Sandy Hook Unit	NA
Motor Vehicle Air Conditioning	**292**
Staten Island Unit	111
Jamaica Bay Unit	123
Sandy Hook Unit	58

Note: Totals may not sum due to independent rounding.
NA = Not applicable.

4.4.1 Stationary Refrigeration and Air Conditioning

Currently there are no HFC emissions from the stationary refrigeration and air conditioning equipment at Gateway National Recreation Area, as the equipment has not yet transitioned from the original ODSs to their substitutes. The refrigerant currently used at Gateway National Recreation Area is HCFC-22. Under the U.S. Clean Air Act Regulations used to implement the Montreal Protocol, HCFC-22 will be disallowed in new refrigeration and air-conditioning equipment in 2010 and completely phased out by 2020. At this time HFCs are seen as one of the most viable alternatives, therefore as current chiller and air conditioning equipment at Gateway National Recreation Area are retired and replaced with HFC-containing equipment, GHG emissions from this source are likely to increase.

4.4.2 Motor Vehicle Air Conditioning

Emissions from the air conditioning systems in cars, trucks, and buses comprised all of the emissions of ODS substitutes estimated at Gateway. In the United States, motor vehicle air conditioners account for over one-third of all emissions from this source category.

Results

Emissions were estimated for 2001 for the Staten Island and Sandy Hook Units, and 2002 for the Jamaica Bay Unit, in keeping with the rest of the inventory. Emissions for park-owned, park-leased, and visitor vehicles for each park unit, and for Headquarters and Park Police vehicles are shown in Table 4.4-2.[29]

Table 4.4-2: Gateway Summary of HFC Emissions from Motor Vehicle Air Conditioning

Source/Park Unit	Emissions (MTCE)
Motor Vehicle Air Conditioning	**292**
Staten Island Unit	**111**
Park-Owned Vehicles	1
Park-Leased Vehicles	+
Visitor Vehicles	110
Headquarters Vehicles	+
Jamaica Bay Unit	**123**
Park-Owned Vehicles	1
Park-Leased Vehicles	+
Visitor Vehicles	119
Park Police Vehicles	2
Sandy Hook Unit	**58**
Park-Owned Vehicles	1
Park-Leased Vehicles	1
Visitor Vehicles	56

Note: Totals may not sum due to independent rounding.
+Does not exceed 0.5 MTCE.

Methodology

To estimate emissions from this source category, information on the total number of vehicles and the year of manufacture were collected first. The year of manufacture is important because it was assumed that the transition from the original CFC-12 refrigerant to the alternative HFC-13—a refrigerant in new systems—began in 1992 and was completed in 1994. Therefore, this analysis assumed that (a) all vehicles manufactured prior to 1992 do not use HFCs as the refrigerant; (b) one third of all vehicles manufactured use the HFC refrigerant in 1992 because in that year one third of the transition was completed; (c) two thirds of all vehicles manufactured in 1993 use HFC-134a because two thirds of the transition was completed in 1993; and (d) thus, all vehicles with air conditioning systems manufactured in 1994 or later use HFC-134a as the refrigerant.

[29] Note that for the purposes of aggregating inventory results by park unit, Headquarters vehicles are included in Staten Island totals, while Park Police vehicles are included in Jamaica Bay totals.

To estimate the number of vehicles for each vehicle type (park-owned, park-leased, visitor, Headquarters, and Park Police) at each age category (pre-1992, 1992, 1993, post-1993), the number of vehicles in each vehicle class[30] was multiplied by the summed percentage of vehicles at each age distribution. Jamaica Bay provided vehicle fleet specific age distributions (Demers 2003), which were used for the Jamaica Bay Unit. Because the Staten Island and Sandy Hook units were unable to provide such detailed information, the U.S. default vehicle age distribution (EPA 2003) was assumed for these units. These distributions are consistent with those provided in Section 4.3.1 (CH_4 and N_2O from Highway Vehicles).

Once the vehicle age distribution was determined, emissions from all park-owned, park-leased, Headquarters, and Park Police vehicles were calculated by multiplying the number of vehicles in each age category by the:

- percent assumed to have air conditioning (95 percent for all types and years) based on Baker (1999);
- emission factor, expressed as the percent lost from leaks and servicing (9.9 percent leak plus 0.9 percent from servicing) from EPA (2003b);
- percent of the age class of vehicles that have completed the transition, based on year of manufacture, (zero for pre-1992, one-third for 1992, two-thirds for 1993, or 100 percent for 1994 or later) from EPA (2003b); and
- charge size (1.3 kg for all vehicles) from EPA (2003b).

A similar methodology was followed for visitor vehicle emission calculations. The only differences in calculations included:

- emission factor reflects leaks only (9.9 percent) and does not include service emissions because visitor vehicles were assumed to be serviced outside the park; and
- emissions were divided by 365 in order to only include emissions for one day of the year, as it was assumed that each visitor vehicle was in the park for only one day.

Data Sources

A variety of data sources were utilized in determining the inputs for the emission calculations for this source. Table 4.4-3 presents the sources of activity data and emission factors used in the emission calculations for motor vehicle air conditioning.

[30] Vehicle classes at Gateway include: light-duty gas vehicles (LDGV), light-duty diesel vehicles (LDDV), light-duty gas truck (LDGT), light-duty diesel truck (LDDT), heavy-duty gas vehicle (HDGV), and heavy-duty diesel vehicle (HDDV).

Table 4.4-3: Data Sources for Emission Calculations for Motor Vehicle Air Conditioning

Source/Park Unit	Data Source
Motor Vehicle Air Conditioning	
All Units	
Annual Leakage Emission Factor	EPA, 2003b.
Air Conditioning Charge Size (kg)	EPA, 2003b.
Percent of Vehicles with Air Conditioning	Baker, 1999.
Average U.S. Vehicle Age Distribution	EPA, 2003a.
Staten Island Unit	
Number of Park-Owned Vehicles	Dexter, 2003.
Number of Park-Leased Vehicles	Dexter, 2003.
Number of Visitor Vehicles	Lancos, 2003.
Number of Vehicles at Headquarters	Dexter, 2003.
Jamaica Bay Unit	
Age and Number of Park-Owned Vehicles	Demers, 2003.
Age and Number of Park-Leased Vehicles	Demers, 2003.
Number of Visitor Vehicles	Lancos, 2003.
Age and Number of Park Police Vehicles	Piccolo, 2003.
Sandy Hook Unit	
Number of Park-Owned Vehicles	Hansen, 2003.
Number of Park-Leased Vehicles	Barthell, 2003.
Number of Visitor Vehicles	Lancos, 2003.

4.5 AGRICULTURE (FERTILIZER USE)

Results

Agricultural sources of GHG emissions include enteric fermentation, manure management, rice cultivation, agricultural soil management, and field burning of agricultural residues. Agricultural soil management is the only agricultural source included in the Gateway inventory because rice cultivation and agricultural residue burning do not occur at Gateway, and enteric fermentation and manure management sources were considered negligible.[31] The agricultural soil management source category includes several types of agricultural activities; however, only fertilizer use was quantified, as other sub-categories (e.g., histosol cultivation, nitrogen-fixing crops) are not applicable to the park.

N_2O emissions from agriculture (i.e., fertilizer use) comprised 0.6 percent of total GHG emissions from Gateway National Recreation Area. Of the 46 MTCE emitted from this source within the park boundaries, Staten Island Unit, Jamaica Bay Unit, and Sandy Hook Unit accounted for roughly 0.04, 98, and 2 percent, respectively. The emissions from the Staten Island and Sandy Hook units were minimal, together totaling less than 1 MTCE, as seen in Table 4.5-1. The majority of emissions, nearly 46 MTCE, were from the Jamaica Bay Unit, which reported the highest consumption of fertilizer. However, the data provided on fertilizer use were very limited, and it is possible that larger quantities were used in other units, but not reported.

Table 4.5-1: Gateway Summary of N_2O Emissions from Agriculture

Source/Park Unit	Emissions (MTCE)
Fertilizer Use	**46.46**
Staten Island Unit	0.02
Jamaica Bay Unit	45.56
Sandy Hook Unit	0.88

Methodology

N_2O emissions from fertilizer use were calculated according to the methodology described in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003), which is consistent with the *Revised 1996 IPCC Guidelines* (1997), the IPCC *Good Practice Guidance* (2000), and the methodology in the *EIIP State Guidance*.[32] Total emissions include direct emissions from applied nitrogen (N) and indirect emissions from volatilization[33] and leaching and runoff of applied N.

[31] There are very few horses at the park.
[32] The N content factors for organic and manure fertilizers are different in the EIIP Guidance. The values used in this report are those used in the U.S. Inventory.
[33] Volatilization describes the process whereby some of the N applied to the soil volatilizes and enters the atmosphere as NO_x and NH_3. It later returns to the soil as part of atmospheric deposition, increasing N_2O production.

Estimates of direct emissions were based on the amount of N applied to soils through synthetic fertilizer, organic fertilizer, and manure used as fertilizer.[34] Synthetic fertilizer was used only in the Staten Island Unit, organics were applied in both the Jamaica Bay and Sandy Hook units, and manure was applied as fertilizer only in the Jamaica Bay Unit. To calculate direct emissions, the quantity of N applied to soils was estimated. Synthetic fertilizers were reported in units of N, but values of N from organic and manure fertilizer were calculated by multiplying tons of fertilizer by their respective N contents (3.7 percent for organics and 0.5 percent for manure) and converting to kilograms. These quantities of applied N from all fertilizers were then reduced by 10 percent (for synthetic fertilizer) or 20 percent (for organics/manure) to adjust for volatilization. The resulting values, in kilograms of unvolatilized N, were then multiplied by the emission factor for direct emissions from applied N (1.25 percent) and converted to MTCE.

To calculate indirect emissions, 10 percent of the total N applied (as calculated for direct emissions) from synthetics and 20 percent for organics/manure were assumed to have volatized, and 30 percent were assumed to have leached or runoff. Indirect emission factors, 1 percent for volatilized N and 2.5 percent for leaching and runoff, were then applied to the resulting quantities of N to calculate N_2O emissions from each of the two indirect pathways. (These emission factors represent the quantity of volatilized and leached/runoff N that is emitted to the atmosphere as N_2O.) The emission estimates were then converted to MTCE and summed with the direct emissions (calculated above) to determine total emissions from fertilizer use.

Data Sources

The fertilizer use data used in the calculations is provided in Table 4.5-2. Activity data on fertilizer consumption were obtained from several sources. National Park Service employees at each park unit provided activity data on quantity or cost of fertilizer used. The Staten Island and Sandy Hook Units provided fertilizer expenditure data, while the Jamaica Bay Unit provided organic and manure fertilizer tonnage data (Dexter, Diodato, McCarthy 2003). Fertilizer price estimates from the USDA's National Agricultural Statistics Service, as provided by the Fertilizer Institute's website (TFI 2003), and an AmeriGrow vendor (Madow 2003) were used to calculate quantity of fertilizer from the amount of money spent. N contents were obtained from the Association of American Plant Food Control Officials (2000, 2002). All other emission-calculating factors are default values from the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (1997).

The method for estimating both direct and indirect emissions from this source is based on the quantity N applied to the soil. Because the quantity of fertilizer for the Staten Island Unit was not known, it was derived from the money spent on fertilizer and the price of fertilizer. Staten Island personnel reported that they purchase fertilizer labeled 10-4-8, which refers to an all-purpose tree and shrub fertilizer that is 10 percent N. Thus, the dollar amount spent on fertilizer was divided by the average price per kilogram (kg) and then multiplied by 10 percent to yield 7.27 kg N. The quantity of fertilizer used at Sandy Hook was calculated by contacting the fertilizer vendor for a conversion of the park unit's expenditure data into pounds of fertilizer, which were then converted into tons. An organic fertilizer N content from *Commercial Fertilizers 2001* (AAPFCO/TFI 2002) was then applied to yield 369 kg N applied.

[34] Manure is technically a type of organic fertilizer, but it is treated as a separate category in GHG inventories to avoid double-counting, and here to account for its different N content.

For further detail on the sources of activity data and factors used in emission calculations for fertilizer use, see Table 4.5-3.

Table 4.5-2: Gateway Fertilizer Use Data

Source/Park Unit	Quantity Used (kg N/yr)
Staten Island Unit	
Synthetic Fertilizers	7
Organics	NA
Manure	NA
Jamaica Bay Unit	
Synthetic Fertilizers	NA
Organics	16,783
Manure	2,268
Sandy Hook Unit	
Synthetic Fertilizers	NA
Organics	369
Manure	NA

Note: NA = Not applicable.

Table 4.5-3: Gateway Summary of Agricultural Data Sources

Source/Park Unit	Data Source
All Units	
Percentages of fertilizer lost to volatilization	IPCC/UNEP/OECD/IEA, 1997.
N content of fertilizer	AAPFCO/TFI, 2002.
N content of manure used as fertilizer	AAPFCO, 2000.
N_2O emission factors	IPCC/UNEP/OECD/IEA, 1997.
Leaching/runoff percentages	IPCC/UNEP/OECD/IEA, 1997.
Staten Island Unit	
Fertilizer Consumption Data	Dexter, 2003; TFI, 2003.
Jamaica Bay Unit	
Fertilizer Consumption Data	McCarthy, 2003.
Sandy Hook Unit	
Fertilizer Consumption Data	Diodato, 2003; Madow, 2003.

4.6 WASTE

Solid and liquid wastes generated at Gateway lead to GHG emissions both inside and outside the park boundaries. These emissions include landfilling and wastewater treatment. GHG emissions from the waste sector comprised roughly 1 percent of total GHG emissions from Gateway National Recreation Area, including CH_4 emissions of 73 MTCE and N_2O emissions of 33 MTCE. Of the 106 MTCE emitted from waste activities, landfills accounted for 32 percent and wastewater treatment accounted for 68 percent. Only 7 percent of emissions from this source occurred within park boundaries, and the remainder occurred "downstream" at landfills and wastewater treatment plants responsible for managing Gateway's solid and liquid wastes. Table 4.6-1 presents landfill and wastewater emissions by gas for each park unit.

Table 4.6-1: Gateway Summary of Emissions from Waste

Source/Park Unit	Emissions (MTCE)		
	CH_4	N_2O	Total
Waste Total	**73**	**33**	**106**
Landfills	**34**	**NA**	**34**
Staten Island Unit	14	NA	14
Jamaica Bay Unit	16	NA	16
Sandy Hook Unit	4	NA	4
Wastewater	**39**	**33**	**72**
Staten Island Unit	18	12	31
Jamaica Bay Unit	20	13	34
Sandy Hook Unit	NA	8	8

Note: Totals may not sum due to independent rounding.
NA= Not applicable.

4.6.1 Landfills

Results

The decomposition of municipal solid waste (MSW) in landfills produces CH_4, a GHG that is estimated to be 21 times as potent as CO_2. Operations at landfills can reduce net emissions through the collection and combustion of CH_4 gas. Although there were no active landfills collecting waste at Gateway during 2001 or 2002, this inventory quantifies the CH_4 emitted from waste generated at Gateway and disposed at landfills outside the park.[35] Total GHG emissions from landfilled MSW generated at Gateway were 34 MTCE, as seen in Table 4.6-2.

Table 4.6-2: Gateway Summary of Direct CH_4 Emissions from Landfills

Source/Park Unit	Emissions (MTCE)
Landfills	**34**
Staten Island Unit	14
Jamaica Bay Unit	16
Sandy Hook Unit	4

The Staten Island, Jamaica Bay, and Sandy Hook units each accounted for 42, 46, and 11 percent of these emissions, respectively. Emissions from landfilled MSW generated at the Sandy Hook Unit were

[35] Emissions from waste disposed at landfills outside of park boundaries can be considered indirect, as they are not directly within the park's control. However, given the strong relationship between park waste disposal practices and "downstream" emissions from

significantly lower than emissions from the other units for a few reasons. First, less waste was generated at Sandy Hook relative to the rest of the park. Secondly, the landfill receiving Sandy Hook's waste (i.e., Monmouth Landfill) contains a CH_4 recovery system with a higher capture rate than the landfill receiving waste from Staten Island and Jamaica Bay (i.e., Fresh Kills Landfill[36]). The following sections describe the methodology and data sources used to calculate the emissions from this source for Gateway.

Methodology

In accordance with the EPA's *Emission Inventory Improvement Program Guidelines, Vol. VIII Estimating Greenhouse Gas Emissions* (2003), CH_4 emissions from landfills were calculated as the total amount of CH_4 generated by each unit's MSW disposed, minus the amount recovered by landfill gas (LFG) projects and the amount of CH_4 oxidized through the landfill surface. The following sections describe each step in the methodology for each park unit, as we had to employ different methods to accommodate the data provided.

Waste Generation

Sandy Hook Unit

Sandy Hook provided estimates on MSW generated in tons for 2001 (Diodato 2003); no further calculations were needed to calculate waste generation at this unit.

Staten Island Unit

The amount of waste generated for the Staten Island Unit was estimated based on information on the park unit's refuse receptacles (Dexter 2003). For each receptacle, the total volume was multiplied by the number of times it was emptied per year, and then the totals for all receptacles were summed. Staten Island reported that the receptacles were emptied twice a month in winter and 3 times a month in summer and we assumed that each season comprises 6 months. Based on these parameters, we could estimate that the containers are emptied 30 times each year. It was further assumed that each receptacle was full when emptied. The following equation outlines the calculations used to obtain the volume of waste generated for the Staten Island Unit:

Total volume waste generated (cubic yards) = (4 large containers x 30 cubic yards/large container x 30 times emptied/yr) + (10 small containers x 5 cubic yards/small container x 30 times emptied/yr)

To estimate tonnage of waste generated, the total volume of waste generated was multiplied by the density of uncompacted MSW, or 0.05 short tons/cubic yard (EPA 1998), as shown below:

Total waste generated (short tons) = Total volume generated (cubic yards) x 0.05 short tons/cubic yard

Jamaica Bay Unit

The Jamaica Bay Unit was unable to provide data on MSW generated, but did provide data on park population throughout the year (Lancos 2003, Saslaw 2003). These data enabled us to estimate waste generation on a per capita basis. Since the park population varies by season, we first estimated the *average* daily population. Average visitor population was calculated by dividing the total annual

landfills, actions taken to reduce waste disposal at Gateway may cost-effectively reduce GHG emissions from landfills.

[36] Fresh Kills, the destination landfill for the Jamaica Bay and Staten Island units, stopped accepting MSW after March 22, 2001. To simplify our methods, we calculate 30-yr WIP as if Fresh Kills had been accepting waste throughout all of 2001 and 2002. We expect that this methodology will not have a significant impact on our estimations for two reasons: 1) all waste generated after March 22, 2001 was likely landfilled somewhere else, so it still would have produced CH_4; and 2) because we calculate waste landfilled over a 30-yr period, the units' MSW generated in 2001 and 2002 represent a relatively small percentage of their total WIP; thus the difference in CH_4 emissions attributed to the MSW being disposed at another landfill would be minor.

visitor population (4,129,068 visitors) by 365 days/yr; this calculation yielded an average daily population of 11,313. The average number of year-round employees (80) was then added to obtain the average daily park population of 11,393 people.

Next, using population information and the estimated MSW generation for the other two park units, we were able to calculate the per capita tons generated at the Sandy Hook and Staten Island units. These two per capita tons landfilled (PCTL)[37] values were then averaged and multiplied by the average daily population for the Jamaica Bay Unit to estimate MSW generated for this third unit, as shown below:

Total MSW generated (tons) = average daily population x average per capita tons generated at Staten Island and Jamaica Bay

Waste generation tonnages provided by Sandy Hook and calculated for Staten Island and Jamaica Bay, as detailed above, are provided in Table 4.6-3.

Table 4.6-3: Gateway Waste Generation

Park Unit	Waste Generated (short tons)
Staten Island Unit	255[a]
Jamaica Bay Unit	273[a]
Sandy Hook Unit	149

[a] Calculated generation.

Waste-in-Place Attributable to Each Unit's MSW

The methodology for estimating landfill CH_4 emissions assumes that MSW produces CH_4 over a period of approximately 30 years from the date of disposal (EPA 2003a). For any given year, CH_4 produced at a landfill is due to the waste that has accumulated over the last 30 years; thus, an estimate of 30-year waste-in-place (WIP) in short tons was used to determine CH_4 emissions. To obtain a 30-year WIP estimate for each park unit, we estimated the amount of waste landfilled during the inventory year (2001 for the Staten Island and Sandy Hook units; 2002 for the Jamaica Bay Unit) and then projected back 30 years.

First, the amount of waste recycled was subtracted from the total MSW generated. The only unit that provided recycling data, the Sandy Hook Unit, reported that 11.3 percent of its MSW was recycled in 2001. Assuming that all park units recycle the same percentage of their MSW[38], we multiplied 11.3 percent by each unit's MSW generated, and subtracted this amount from the respective unit's total MSW generated to obtain the tonnage of MSW landfilled for each park unit. This calculation is shown in the equation below:

MSW landfilled (tons) = MSW generated – (11.3% x MSW generated)

Park population data were available for only one year for each unit; however, population for the past 30 years was needed to estimate 30-yr WIP. The average daily population of each park unit for the past 30 years was estimated by assuming that the same percent of the U.S. population visits Gateway each year. Each unit's average daily population was divided by the national population in 2001, and this

[37] PCTL refers to the amount, in tons, of waste per person that is placed in a landfill each year.
[38] This assumption is error-prone. Sandy Hook is mandated by state to recycle, but the other units currently are not. We would appreciate suggestions on improving the accuracy of our recycling assumptions.

ratio was multiplied by the annual national population estimates for the past 30 years (U.S. Census 1995, 1999, 2000, 2002).[39] This calculation is shown in the equation below:

Average daily park population Year$_n$ = U.S. population Year$_n$ x (average daily park unit population 2001/ U.S. population 2001)

Each unit's per capita waste landfilled in 2001 was calculated by dividing the amount landfilled by the unit's population. Historical PCTL were then estimated using national average growth rates (See Table 4.6-4), following the equation below:

PCTL Year$_n$ = PCTL Year$_{n+1}$ x (1-(PCTL growth rate for Year$_n$))

Table 4.6-4: U.S. Per Capita Tons Landfilled Growth Rate by Decade

-0.02 if 1990 $\leq$ t > 2000
0.003 if 1980 $\leq$ t > 1990
0.020 if 1970 $\leq$ t > 1980
0.030 if 1960 $\leq$ t > 1970

Source: EPA 2003a; EPA 2003b.

Once the PCTL was calculated for each year, we multiplied the PCTL by the park unit population for each year to obtain yearly estimates for MSW landfilled. MSW landfilled for the past 30 years were summed to obtain the 30-yr WIP attributed to each park unit.

Gross CH_4 Generation

MSW generated at Gateway was assumed to have been disposed in either Fresh Kills Landfill, New York, for the Staten Island and Jamaica Bay units, or Monmouth County Landfill, New Jersey, for the Sandy Hook Unit. Both of these landfills are large, non-arid landfills. Based on the following equation from the EIIP guidelines for CH_4 generation from large, non-arid landfills, and WIP estimates for each landfill provided by EPA's Landfill Methane Outreach Program (LMOP), we calculated the CH_4 generated at Fresh Kills and at Monmouth County[40].

CH_4 generated (tons) = 3,218 tons CH_4 + [0.002002 tons CH_4/yr/ton WIP x WIP (tons)]

We then multiplied this number by the ratio of WIP attributed to each unit over the total WIP at the unit's respective landfill. This calculation provides the CH_4 generation due to each unit's MSW.

CH_4 generated$_{unit\ X}$ = CH_4 generated$_{unit's\ destination\ landfill}$ x WIP$_{unit}$/WIP$_{unit's\ destination\ landfill}$

CH_4 Avoided from Landfill Gas Projects

Both Fresh Kills and Monmouth County Landfills have operational landfill-gas-to-energy (LFGTE) projects that partly offset their CH_4 emissions. LMOP provides estimates on CH_4 emissions avoided due to these projects (EPA 2003b). We multiplied the ratio of WIP due to each unit over the total WIP at the unit's respective landfill by the estimated CH_4 emissions avoided by that landfill's LFGTE project. The product is the CH_4 emissions from each unit that are avoided due to the LFGTE project.

CH_4 avoided$_{unit}$ = CH_4 avoided$_{unit's\ destination\ landfill}$ x WIP$_{unit}$/WIP$_{unit's\ destination\ landfill}$

The amount of CH_4 avoided was then subtracted from the gross CH_4 emissions.

[39] Please note that 2002 was used for Jamaica Bay.
[40] We used the WIP estimate at Monmouth County Landfill for 1998, as reported at http://www.epa.gov/lmop/pdf/nj_jan.pdf. Later estimates decrease the WIP significantly, and result in negative CH_4 emissions when landfill gas projects are taken into account.

Conversion to MTCE

CH_4 emissions were then converted from tons CH_4 to MTCE by multiplying by the GWP of CH_4 of 21, the molecular weight ratio of carbon to CO_2 (12/44), and ratio of metric tons to short tons (0.9072).

CH_4 Oxidation

Approximately 10 percent of the CH_4 generated in landfills is oxidized,[41] according to Liptay et al. (1998). Consistent with EIIP Guidelines, landfill emission estimates were multiplied by 90 percent. This last calculation resulted in the final estimates for each unit's CH_4 emissions from landfills.

Data Sources

The Sandy Hook Unit provided data on the tonnage of waste generated and disposed in 2001 (Diodato 2003), and the Staten Island Unit provided information on the volume of waste generated (Dexter 2003). Although they were unable to provide data on waste generation, the Jamaica Bay Unit provided population information (Lancos 2003, Saslaw 2003) that was utilized as described in the methodology section. LFGTE data were obtained from EPA's LMOP database (EPA 2003b). Estimates on national population for the past 30 years were obtained from the U.S. Census Bureau (1995, 1999, 2000, 2002). Table 4.6-5 provides the sources of activity data, factors, and equations used in the estimation of CH_4 from landfills.

Table 4.6-5: Data Sources for Estimation of CH_4 Emissions from Landfills

Source/Park Unit	Data Source
All Units	
MSW Density Factor	EPA, 1998.
CH_4 Generation Equation	EPA, 2003a.
CH_4 & Fresh Kills Data	EPA, 2003b.
CH_4 Oxidation Rate	Liptay et al., 1998.
U.S. Population Data	U.S. Census Bureau, 1995, 1999, 2000, and 2002.
Staten Island Unit	
Waste Receptacle Information	Dexter, 2003.
Jamaica Bay Unit	
Population Data	Saslaw, 2003; Lancos, 2003.
Sandy Hook Unit	
Waste Generation Data	Diodato, 2003.

[41] Some of the CH_4 produced in landfills reacts with oxygen before it leaves the landfill surface. This reaction, called oxidation, results in byproducts of H_2O and CO_2; thus, not all of the CH_4 generated in a landfill is actually emitted into the atmosphere

4.6.2 Wastewater Treatment

Results

The treatment of domestic wastewater produces both CH_4 and N_2O emissions. Total GHG emissions from wastewater treatment related to activities at Gateway were 72 MTCE for the years inventoried, as shown in Table 4.6-6. This source accounted for 68 percent of waste-related GHG emissions.

The Staten Island, Jamaica Bay, and Sandy Hook units accounted for 43, 47, and 11 percent, respectively, of total wastewater GHG emissions.

Table 4.6-6: Gateway Summary of Direct GHG Emissions from Wastewater

Source/Park Unit	Emissions (MTCE)		
	CH_4	N_2O	Total
Emissions: Wastewater	**39**	**33**	**72**
Staten Island Unit	18	12	**31**
Jamaica Bay Unit	20	13	**34**
Sandy Hook Unit	NA	8	**8**

Note: Emissions from the Sandy Hook Unit occurred within the park unit, while emissions from the Staten Island and Jamaica Bay units took place outside the park but were attributed to activities at those units.
Emissions may not sum due to independent rounding.
NA = Not applicable because all of the wastewater at Sandy Hook was treated aerobically. CH_4 emissions result from anaerobic treatment processes.

Methodology

The methods used to estimate CH_4 and N_2O emissions from the treatment of wastewater generated at Gateway were adapted from EPA's Emission Inventory Improvement Program (EIIP) Guidelines (EPA 2003a). CH_4 emissions from wastewater were estimated based on biochemical oxygen demand (BOD_5)[42] generation at each unit and on the level of anaerobic treatment, while N_2O emissions were based on protein consumption. The sections below describe these methods in more detail, first for CH_4 and then for N_2O.

<u>CH_4 Emissions</u>

To estimate CH_4 emissions from municipal wastewater, we estimated total BOD_5 produced, annual quantity of BOD_5 treated anaerobically, and gross annual CH_4 emissions from wastewater treatment, and converted annual CH_4 emissions from wastewater to MTCE, as outlined below.

Biochemical Oxygen Demand

In order to capture a Gateway-specific BOD_5 generation rate per day, data from the wastewater treatment facility located at the Sandy Hook Unit were used to estimate a park visitor wastewater generation rate. To calculate this value, the daily flow volume at the Sandy Hook wastewater treatment plant was divided by the average daily population to obtain an estimate of 10.7 gallons of wastewater generated per park visitor per day. This value was then multiplied by the typical wastewater BOD_5

[42] BOD represents the amount of oxygen that would be required to completely consume the organic matter contained in the wastewater through aerobic decomposition processes (U.S. EPA 2002). A standardized measurement of BOD is the "5-day test"

concentration value of 814 mg/gallon (EPA 2000)[43] to obtain a park BOD_5 generation rate of 0.01 kg per visitor per day. To estimate daily BOD_5 generation, the per capita BOD_5 generation rate was multiplied by the average number of daily visitors to each park unit. These calculations are shown in the equations below:

WW Generation (gal/capita/day) = Gallons of WW Treated (gal/day) / Avg. Daily Population

Park BOD_5 Generation Rate (kg/capita/day) = WW Generation (gal/capita/day) x BOD_5 Content (mg/gal) /1000 mg/kg

BOD_5 Generated (kg/day) = Population x Park BOD_5 Generation Rate (kg/capita/day)

Annual Quantity of BOD_5 Treated Anaerobically

CH_4 is produced when wastewater is treated anaerobically (in the absence of oxygen). To obtain quantity of annual BOD_5 treated anaerobically, the BOD_5 generated (kg/day) was multiplied by the fraction of wastewater BOD_5 treated anaerobically and by 365 days per year. The wastewater treatment facility at the Sandy Hook Unit utilizes a primary clarifier and trickling filter process combined with natural attenuation in a nearby lagoon. This treatment train is aerobic in nature; therefore, we assumed that zero percent of the BOD_5 treatment at this facility was anaerobically treated. Wastewater generated at Staten Island and Jamaica Bay was treated by the New York City Sewer Authority. Because larger wastewater treatment facilities typically utilize sludge handling techniques such as anaerobic digestion, a default value of 16.25 percent was used to capture the fraction of anaerobic treatment (EPA, 2003a). This calculation is shown in the equation below:

Annual BOD_5 Treated Anaerobically (kg/yr) = BOD_5 Generated (kg/day) x Fraction of Wastewater BOD_5 Treated Anaerobically (%) x 365 (days/yr)

Gross Annual CH_4 Emissions

To obtain the total CH_4 emissions (in kg), the quantity of BOD_5 treated anaerobically was multiplied by the CH_4 emission factor of 0.6 kg CH_4/kg BOD_5, as recommended in the EIIP Guidelines. This calculation is shown below:

CH_4 Emissions (kg CH_4) = BOD_5 Treated Anaerobically (kg BOD_5/yr) x CH_4 Emissions Factor (kg CH_4/kg BOD_5)

Conversion to MTCE

In order to convert the emissions in units of kg of CH_4 to MTCE, the gross emissions were multiplied by 0.001 metric tons per kg, by the mass ratio of carbon to CO_2 (12/44), and by the GWP for CH_4 of 21. This final CH_4 calculation is shown in the equation below:

CH_4 Emissions (MTCE) = CH_4 Emissions (kg CH_4) x 0.001 metric tons/kg x (12/44) x 21

N_2O Emissions

This section provides the method for estimating N_2O emissions from municipal wastewater attributable to Gateway. To estimate emissions from this source, we estimated annual park per capita

denoted as BOD_5.

[43] Reference suggests 215 mg/l, which was converted to 814 mg/gal.

consumption of protein, annual park per capita consumption of N in protein, and annual N_2O emissions from wastewater treatment, and converted annual N_2O emissions to MTCE.

Annual Park Per Capita Consumption of Protein

Protein consumption data related to wastewater generation at the park units was unavailable. In order to capture a Gateway-specific protein consumption rate, the estimated park BOD_5 generation rate (described above) was used as a tool to apportion default data on wastewater generation used for state and national inventories to the portion of an individual's day that might be spent at the park. The estimated park BOD_5 generation rate was divided by the default BOD_5 generation rate to create a park-to-default ratio. This ratio was used to compare national average data values to "park" data values. The 2001 default annual protein consumption value of 41.6 kg/capita/year from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001* (EPA 2003c) was multiplied by this ratio to create a park protein consumption value. This default value was assumed to be the same for all park units. These calculations are shown in the equations below:

Park-to-Default Ratio = Park BOD_5 Generation / National Default BOD_5 Generation

Park Per Capita Protein Consumption (kg) = Default National Per Capita Protein Consumption x Park-to-Default Ratio

Estimation of Annual Consumption of N

To obtain the annual per capita consumption of N in protein, the annual per capita consumption of protein was multiplied by the default proportion of N in protein of 16 percent, as recommended by the EIIP Guidelines (EPA 2003a). This calculation is shown the equation below:

Park Per Capita N Consumption (kg) = Park Protein Consumption (kg/capita/year) x 16% N in Protein

To obtain the park's annual consumption of N in protein for each unit, the annual park per capita consumption of N in protein was multiplied by the average daily park population. This calculation is shown the equation below:

Annual Consumption of N in Protein (kg N) = Park Per Capita N Consumption (kg/capita) x Population

Estimate Each Unit's Annual N_2O Emissions from Wastewater Treatment

The annual consumption of N in protein for each unit was multiplied by the emission factor of 0.01 kg N_2O-N/kg N in protein to estimate the annual emissions of N_2O in terms of N. These emissions (in kg N_2O-N) were then multiplied by the ratio of the molecular weight of N_2O to the atomic weight of the N contained in N_2O (44/28) to yield emissions in kg N_2O, as shown in the equation below:

Annual Emissions of N_2O from Wastewater (kg N_2O) = Annual Consumption of N in Protein (kg N) x Emission Factor (kg N_2O-N/kg N) x 44/28

Conversion to MTCE

In order to convert emissions in kilograms of N_2O to units of MTCE, the gross emissions were multiplied by 0.001 metric tons per kg, by the ratio of carbon to CO_2 (12/44), and by the GWP of N_2O (310). This final N_2O calculation is shown in the equation below:

N_2O Emissions (MTCE) = N_2O Emissions (kg N_2O) x 0.001 metric tons/kg x (12/44) x 310

Data Sources

The Sandy Hook Unit provided wastewater treatment data for the plant located at its site, as shown in Table 4.6-7. Gateway park personnel provided average population data that were also used in estimation of wastewater treatment GHG emissions (See Table 4.6-8). Table 4.6-9 provides the sources for activity data and factors utilized to calculate GHG emissions from wastewater treatment.

Table 4.6-7: Wastewater Treatment Data

Park Unit	Wastewater Treated (gal/year)	Design Capacity (gal/year)
Sandy Hook WWTP	25,000,000	102,200,000

Source: Cloonan 2003.

Table 4.6-8: Gateway Average Daily Population Data

Park Unit	Average Daily Population
Staten Island Unit	10,356
Jamaica Bay Unit	11,393
Sandy Hook Unit	6,415

Source: Lancos 2003; Saslaw 2003.

Table 4.6-9: Data Sources for Estimation of GHG Emissions from Wastewater

Park Unit/Source	Data Source
Direct Emissions: Fuel Combustion	
All Units	
Methodology and Default Values	EPA, 2003a. Chapter 14.
BOD_5 Concentration	EPA, 2000.
Annual Protein Consumption, 2001	EPA, 2003c.
Park Population Data	Lancos, 2003; Saslaw, 2003.
Sandy Hook Unit	
WWTP Flow Data	Cloonan, 2003.

5 REFERENCES

5.1 EXECUTIVE SUMMARY

Lancos, John. 2003. Gateway visitation data gathered from John Lancos, Gateway National Recreation Area, e-mail: John_Lancos@nps.gov. March-April.

Saslaw, Dena. 2003. Gateway employee numbers gathered from Dena Saslaw, Gateway National Recreation Area, phone: (718) 354-4613. March-April.

5.2 INTRODUCTION

EPA. 2003. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*. U.S. Environmental Protection Agency. Washington, DC.

IPCC. 1996. *Climate Change 1995: The Science of Climate Change*. Report prepared for IPCC by Working Group 1. Intergovernmental Panel on Climate Change, Organization for Economic Co-Operation and Development. Paris, France.

Lancos, John. 2003. Gateway visitation data gathered from John Lancos, Gateway National Recreation Area, e-mail: John_Lancos@nps.gov. March-April.

NPS. 2001. *Air Emissions Inventory Preparation Protocol*. National Park Service Air Resources Division. EA Engineering, Science and Technology. November 2001.

Saslaw, Dena. 2003. Gateway employee numbers gathered from Dena Saslaw, Gateway National Recreation Area, phone: (718) 354-4613. March-April.

5.3 CRITERIA AIR POLLUTANTS

Stationary Point and Area Sources

Collier, Brian. 2003. Jamaica Bay Unit stationary source data gathered from Brian Collier, Gateway National Recreation Area, phone: (718) 338-3706. March-April.

Cloonan, Tom. 2003. Sandy Hook Unit wastewater treatment plant data gathered from Tom Cloonan, Gateway National Recreation Area, phone: (732) 872-5927. March-April.
Dexter, John. 2003. Staten Island Unit stationary source data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

EPA. 1998. EPA Compilation of Air Pollutant Emission Factors 1998 (AP-42). Chapter 7. Available online at: http://www.epa.gov/ttn/chief/software/tanks.

Hansen, Lou and Pat Diodato. 2003. Sandy Hook Unit stationary source data gathered from Lou Hansen and Pat Diodato, Gateway National Recreation Area, phone: (732) 872-5920. March-April.

IPCC/UNEP/OECD/IEA. 1997. Revised 1996 Guidelines for National Greenhouse Gas Inventories, 3 volumes. Intergovernmental Panel on Climate Change, United Nations Environment Programme, Organization for Economic Co-Operation and Development, International Energy Agency. Paris, France.

NPS. 2001. *Inventory Preparation Plan: NPS Air Emission Inventories*. U.S. Department of the Interior, Washington, DC.

Wolff, Jennifer. 2003. Jamaica Bay Unit area source emissions gathered from Jennifer Wolff, Facilities, Gateway National Recreation Area. March-April.

Mobile Sources

Highway Vehicles

Barthell, Wayne. 2003. Sandy Hook Unit park-leased vehicle data from Wayne Barthell, GSA, phone: 732-906-5605. March-April.

CE-CERT. 2000. Vehicle Type Distribution – Inputs for Mobile 6.2 model developed for previous National Park Service inventories. Center for Environmental Research and Technology, College of Engineering, University of California Riverside.

Clardy, Cal. 2003. Jamaica Bay Unit mobile source data and VMT for Staten Island and Sandy Hook park-owned vehicles gathered from Cal Clardy, Gateway National Recreation Area, phone: (718) 338-3702. March-April.

Demers, Alixandra. 2003. Jamaica Bay Unit mobile source data and VMT for Staten Island and Sandy Hook park-owned vehicles gathered from Alixandra Demers, Gateway National Recreation Area, phone: (718) 338-3338. March-April.

Dexter, John. 2003. Staten Island Unit mobile source data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

EPA. 2003. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*. U.S. Environmental Protection Agency. Washington, DC.

EPA. 2002. MOBILE6 Vehicle Emission Modeling Software. Office of Transportation and Air Quality, U.S. Environmental Protection Agency. Available online at: www.epa.gov/otaq/m6.htm.

ExxonMobil. 2002. U.S. Gasoline Requirements. K.W. Gardner, October 2002. Available online at: http://www.exxon.com/USA-English/Files/US%20Gasoline%20Map%20100102.pdf.

HQ Property Office. 2003. GSA vehicles at the Jamaica Bay Unit gathered from the Headquarters Property Office, Gateway National Recreation Area. March.

Lancos, John. 2003. Gateway visitation data gathered from John Lancos, Gateway National Recreation Area, e-mail: John_Lancos@nps.gov. March-April.

Natural Resources. 2003. Park-leased vehicles at the Staten Island Unit gathered from Natural Resources, HQ, Gateway National Recreation Area. March.

Piccolo, John. 2003. Park Police vehicle fleet data gathered from John Piccolo, Park Police, Gateway National Recreation Area, phone: (718) 354-4600. March-April.

Robinson, Earnestine. 2003. Miller Field road miles data gathered from Earnestine Robinson, Gateway National Recreation Area, phone: 718-351-6988. March-April.

Weather.com. 2003. Monthly Averages for Gateway NRA, NY. Available online at: http://www.weather.com/outlook/recreation/nationalparks/climatology/monthly/GAT

Nonroad Vehicles

Clardy, Cal. 2003. Jamaica Bay nonroad equipment data gathered from Cal Clardy, Gateway National Recreation Area, phone: (718) 338-3702. March-April.

Dexter, John. 2003. Staten Island nonroad equipment data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

EPA. 2002. *The National Emissions Inventory*. *Criteria: Nonroad.* Emissions Monitoring and Analysis Division, Emission Factor and Inventory Group. U.S. Environmental Protection Agency. ftp://ftp.epa.gov/EmisInventory/finalnei99ver2/criteria/

EPA. 2000. *Draft Nonroad Model.* Office of Transportation and Air Quality, U.S. Environmental Protection Agency. http://www.epa.gov/otaq/nonrdmdl.htm#model

Fowler, Harold. 2003. Sandy Hook nonroad equipment and marine data gathered from Harold Fowler, Gateway National Recreation Area, phone: (732) 872-5926. March-April.

McCarthy, Pete. 2003. Jamaica Bay marine data gathered from Pete McCarthy, Gateway National Recreation Area, phone: (718) 338-3827. March-April.

NPS. 2003. 2001 Air Emissions Inventory: Chiricahua National Monument, Arizona. U.S. National Park Service. January.

NPS. 2002. 2000 Air Emissions Inventory: Grand Canyon National Park, Arizona. U.S. National Park Service. September.

Olijnyk, Chris. 2003. Jamaica Bay marine data gathered from Chris Olijnyk, Gateway National Recreation Area, phone: (718) 318-4349. March-April.

5.4 Greenhouse Gas Emissions

CO_2 from Fossil Fuel Combustion

Collier, Brian. 2003. Jamaica Bay Unit stationary source data gathered from Brian Collier, Gateway National Recreation Area, phone: (718) 338-3706. March-April.

Connolly, Eileen. 2003. Sandy Hook Unit purchased electricity data gathered from Eileen Connolly, Gateway National Recreation Area, e-mail: Eileen_Connolly@nps.gov. April.

Demers, Alixandra. 2003. Jamaica Bay Unit mobile source data gathered from Alixandra Demers, Gateway National Recreation Area, phone: (718) 338-3338. March-April.

Dexter, John. 2003. Staten Island Unit stationary source data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

Diodato, Pat. 2003. Sandy Hook Unit data gathered from Pat Diodato, Gateway National Recreation Area, phone: (732) 872-5920. March-April.

EIA. 2003. *Retail Gasoline Historical Prices and Weekly Retail On-Highway Diesel Prices for NYC*. Available online at: http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp.

EIA. 2002. *Annual Energy Review 2001*. Energy Information Administration. U.S. Department of Energy, Washington, DC. DOE/EIA-0384(2001).

EPA. 2003a. Emissions & Generation Resource Integrated Database (eGRID). Office of Atmospheric Programs. U.S. Environmental Protection Agency. Washington, DC. Available online at: http://www.epa.gov/cleanenergy/egrid.htm.

EPA. 2003b. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*. U.S. Environmental Protection Agency. Washington, DC. EPA. 2002a. Climate Leaders Greenhouse Gas Inventory Protocol. Climate Protection Partnerships Division. September. Draft. Available online at: http://www.epa.gov/climateleaders/protocol.html.

EPA. 2002b. *The National Emissions Inventory*. *Criteria: Nonroad.* Emissions Monitoring and Analysis Division, Emission Factor and Inventory Group. U.S. Environmental Protection Agency. ftp://ftp.epa.gov/EmisInventory/finalnei99ver2/criteria/

FHWA. 2002. *Highway Statistics 2001*. Federal Highway Administration, U.S. Department of Transportation. Washington, DC, report FHWA-PL-96-023-annual.

Hansen, Louis. 2003. Sandy Hook Unit data gathered from Louis Hansen, Gateway National Recreation Area, phone: (732) 872-5921. March-April.

McCarthy, Pete. 2003. Jamaica Bay marine data gathered from Pete McCarthy, Gateway National Recreation Area, phone: (718) 338-3827. March-April.

Saslaw, Dena. 2003. Staten Island Unit purchased electricity data gathered from Dena Saslaw, Gateway National Recreation Area, phone: (718) 354-4613. March-April.

Taunton, Rosalia. 2003. Jamaica Bay Unit fuel purchased data gathered from Rosalia Taunton, Gateway National Recreation Area, phone: (718) 338-3709. March-April.

WRI. 2001. GHG Protocol Initiative. World Resources Institute and the World Business Council for Sustainable Development. October. Available online at: http://www.ghgprotocol.org/standard/index.htm.

CH_4 and N_2O from Stationary Combustion

Collier, Brian. 2003. Jamaica Bay Unit stationary source data gathered from Brian Collier, Gateway National Recreation Area, phone: (718) 338-3706. March-April.

Dexter, John. 2003. Staten Island Unit stationary source data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

EPA. 1998. "Compilation of Air Pollutant Emission Factors 1998 (AP-42)", Fifth addition. Available online at: http://www.epa.gov/ttn/chief/software/fire/index.html.

Hansen, Lou and Pat Diodato. 2003. Sandy Hook Unit stationary source data gathered from Lou Hansen and Pat Diodato, Gateway National Recreation Area, phone: (732) 872-5920. March-April.

IPCC/UNEP/OECD/IEA. 1997. *Revised 1996 Guidelines for National Greenhouse Gas Inventories*, 3 volumes. Intergovernmental Panel on Climate Change, United Nations Environment Programme, Organization for Economic Co-Operation and Development, International Energy Agency. Paris, France.

Wolff, Jennifer. 2003. Jamaica Bay Unit area source emissions gathered from Jennifer Wolff, Gateway National Recreation Area. March-April.

CH_4 and N_2O from Mobile Combustion

Barthell, Wayne. 2003. Sandy Hook Unit park-leased vehicle data from Wayne Barthell, GSA, phone: 732-906-5605. March-April.

Collier, Brian. 2003. Jamaica Bay Unit nonroad fuel consumption data gathered from Brian Collier, Gateway National Recreation Area, phone: (718) 338-3706. March-April.

Clardy, Cal. 2003. Jamaica Bay Unit mobile source data and VMT for Staten Island and Sandy Hook park-owned vehicles gathered from Cal Clardy, Gateway National Recreation Area, phone: (718) 338-3702. March-April.

Demers, Alixandra. 2003. Jamaica Bay Unit mobile source data and VMT for Staten Island and Sandy Hook park-owned vehicles gathered from Alixandra Demers, Gateway National Recreation Area, phone: (718) 338-3338. March-April.

Dexter, John. 2003. Staten Island Unit mobile source data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

EPA. 2003. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*. U.S. Environmental Protection Agency. Washington, DC.

EPA. 2002. *The National Emissions Inventory*. *Criteria: Nonroad.* Emissions Monitoring and Analysis Division, Emission Factor and Inventory Group. U.S. Environmental Protection Agency. ftp://ftp.epa.gov/EmisInventory/finalnei99ver2/criteria/

Lancos, John. 2003. Gateway visitation data gathered from John Lancos, Gateway National Recreation Area, e-mail: John_Lancos@nps.gov. March-April.

McCarthy, Pete. 2003. Jamaica Bay marine data gathered from Pete McCarthy, Gateway National Recreation Area, phone: (718) 338-3827. March-April.

Piccolo, John. 2003. Park Police vehicle fleet data gathered from John Piccolo, Park Police, Gateway National Recreation Area, phone: (718) 354-4600. March-April.

Robinson, Earnestine. 2003. Miller Field road miles data gathered from Earnestine Robinson, Gateway National Recreation Area, phone: 718-351-6988. March-April.

Refrigeration and Air Conditioning

Baker, J.A. 1999. *Mobile Air Conditioning: HFC-134a Emissions and Emission Reduction Strategies*. UNEP TEAP HFC/PFC Task Force, Intergovernmental Panel on Climate Change, May 26-28, 1999.

Barthell, Wayne. 2003. Sandy Hook Unit leased vehicle source data gathered from Wayne Barthell, GSA, phone: (732) 906-5605. March-April.

Demers, Alixandra. 2003. Jamaica Bay Unit vehicle source data gathered from Alixandra Demers, Gateway National Recreation Area, phone: (718) 338-3338. March-April.

Dexter, John. 2003. Staten Island Unit vehicle source data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

EPA. 2003a. *Inventory of U.S. Greenhouse Gas emissions and Sinks: 1990-2001*. U.S. Environmental Protection Agency, Washington, DC. EPA 430-R-02-003.

EPA. 2003b. Leak and service rates and charge sizes gathered from the U.S. EPA's Vintaging Model, used to generate emission estimates for the *Inventory of U.S. Greenhouse Gas emissions and Sinks*. Contact Marian Martin Van Pelt, ICF Consulting, phone: (202) 862-2969. April.

Hansen, Louis. 2003. Sandy Hook Unit vehicle source data gathered from Louis Hansen, Gateway National Recreation Area, phone: (732) 872-5921. March-April.

Lancos, John. 2003. Visitor vehicle source data gathered from John Lancos, Gateway National Recreation Area, phone: (718) 354-4560. March-April.

Piccolo, John. 2003. Park police vehicle source data gathered from John Piccolo, Park Police, Gateway National Recreation Area, phone: (718) 354-4600. March-April.

Agriculture

AAPFCO. 2000. *1999-2000 Commercial Fertilizers Data*. American Association of Plant Food Control Officials. ASCII files (obtained from David Terry, Secretary, AAPFCO).

AAPFCO/TFI. 2002. *Commercial Fertilizers 2001*. American Association of Plant Food Control Officials and the Fertilizer Institute. Table 27.

Dexter, John. 2003. Staten Island Unit agriculture data gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

Diodato, Pat. 2003. Sandy Hook Unit agriculture data gathered from Pat Diodato, Maintenance, Gateway National Recreation Area, phone: (732) 872-5920. March-April.

EPA. 2003. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*. U.S. Environmental Protection Agency, Washington, DC.

TFI. 2003. "Average U.S. farm prices of selected fertilizers." The Fertilizer Institute. http://www.tfi.org/Statistics/pricespaidbyfarmers%20.PDF. April.

IPCC. 2000. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.* International Panel on Climate Change, National Greenhouse Gas Inventories Programme Technical Support Unit, Kanagawa, Japan.

IPCC/UNEP/OECD/IEA. 1997. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*. Intergovernmental Panel on Climate Change, United Nations Environment Programme, Organization for Economic Cooperation and Development, International Energy Agency.

Madow, Mike. 2003. AmeriGrow fertilizer data gathered from Mike Madow, AmeriGrow vendor, phone: (860) 283-2869. April.

McCarthy, Pete. 2003. Jamaica Bay Unit agriculture data gathered from Pete McCarthy, Gateway National Recreation Area, phone: (718) 338-3827. March-April.

Waste

Cloonan, Tom. 2003. Sandy Hook Unit wastewater treatment plant data gathered from Tom Cloonan, Gateway National Recreation Area, phone: (732) 872-5927. March-April.

Dexter, John. 2003. Staten Island Unit waste receptacle information gathered from John Dexter, Facilities, Gateway National Recreation Area, phone: (718) 354-4614. March-April.

EPA. 2003a. *EIIP Document Series, Volume VIII: Estimating Greenhouse Gas Emissions.* Emission Inventory Improvement Program, U.S. Environmental Protection Agency. Draft.

EPA. 2003b. *Microsoft Excel version of LMOP landfill and project database, sorted by state, project status, and landfill name*. Landfill Methane Outreach Program, U.S. Environmental Protection Agency, http://www.epa.gov/lmop/projects/lmopdata.xls.

EPA. 2003c. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001.* U.S. Environmental Protection Agency, Washington, DC.

EPA. 2000. Progress in Water Quality. Office of Water, U.S. Environmental Protection Agency, Washington, DC. pp. 2-35.

EPA. 1998. *Announcement and Publication of the Policy for Municipality and Municipal Solid Waste; CERCLA Settlements at NPL Co-Disposal Sites.* Federal Register, 18 February 1998, vol. 63, no. 32, pp. 8197-8201. http://www.epa.gov/fedrgstr/EPA-WASTE/1998/February/Day-18/f4007.htm

Lancos, John. 2003. Gateway visitation data gathered from John Lancos, Gateway National Recreation Area, e-mail: John_Lancos@nps.gov. March-April.

Liptay et al. 1998. *Use of Stable Isotopes to Determine Methane Oxidation in Landfill Cover Soils.* JGR Atmospheres, 103D, pp. 8243-8250.

Saslaw, Dena. 2003. Gateway employee numbers gathered from Dena Saslaw, Gateway National Recreation Area, phone: (718) 354-4613. March-April.

U.S. Census Bureau. 2002. *State Population Estimates: April 1, 2000 to July 1, 2002.* U.S. Census Bureau. http://eire.census.gov/popest/data/states/tables/ST-EST2002-01.php

U.S. Census Bureau. 2000. *Historical National Population Estimates: July 1, 1900 to July 1, 1999*. U.S. Census Bureau. http://eire.census.gov/popest/archives/pre1980/popclockest.txt.

U.S. Census Bureau. 1999. *State Population Estimates and demographic Components of Population Change: April 1, 1990 to July 1, 1999*. U.S. Census Bureau. http://www.census.gov/population/estimates/state/st-99-2.txt.

U.S. Census Bureau. 1995. *Alabama. Population of Counties by Decennial Census: 1900 to 1990*. U.S. Census Bureau. http://www.census.gov/population/cencounts/al190090.txt.